HUMAN PROBLEMS OF INNOVATION IN INDUSTRY

DURING the past two or three decades, there has been a quickening of technological change in British industry. Associated with this change, both as cause and effect, there has been a marked increase in the number of industrial scientists whose role is not merely to perform tests, answer specific practical questions, or evolve minor improvements, but also to innovate, to open up new possibilities whether of production or use. To an unprecedented extent, technical innovation is becoming a 'resource' of industrial firms, like the manual skill of operators or the administrative skill of managers.

This injection of a new element, this resort by firms to research and development as a continuing activity, calls for changes in the structure and method of management. The kind of management organization and practice, including relationships between different levels of management, which will work well when a business is running on an even keel, will not work where technical methods are rapidly changing.

A brief account by Honor Croome describes a study made by Tom Burns and G. M. Stalker between 1955 and 1957 in certain Scottish firms which entered a new business field involving rapid technological development*. It examines the strains which consequently arose in the field of management, and especially the difficulties which were encountered in acquiring the new resources of "Research and Development", and fitting a newly recruited or newly expanded research and development group into the managerial structure.

The firms were mostly those taking part in the scheme initiated by the Scottish Council (Development and Industry) to stimulate the growth of the electronics industry in Scotland. Behind the scheme, and bulking large in its founders' minds, was a particular war-time experience: that of the collaboration between the Telecommunications Research Centre, serving officers of the Royal Air Force and Air Staff officers.

The scheme was formally designed to bridge the gap between the users of electronic products—initially, the Service departments and the Ministry of Supply—and those firms which, although potential producers, had no adequate research team or laboratories and no experience in handling development contracts. One big firm, Ferranti, Ltd., of Edinburgh—which had special expertize in electronics and was the reason for choosing this rather than some other 'growing point' of technology for the experiment—agreed to perform the functions of intermediary, or 'staging point'.

The first contact is generally between the Scottish Council and the management of a particular firm; the initiative may come from either side. The firm is told about possibilities and procedures, and its management is invited to examine the Ferranti laboratory and possibly some Government research stations. There follows a discussion between its management, Ferranti, Ltd., the Scottish Council, and one of the Defence Ministries, with the view of picking a development contract which suits the firm's present activities, technical capacities, and future plans. A suitable contract is one which can be handled by the firm and Ferranti, Ltd., between them. When this is arranged, the new firm engages a number of design engineers, who then work alongside the Ferranti group attached to the contract. When the new team has sufficiently grasped the requirements, the special techniques, and the methods of co-operation involved, it carries on until the contract is fulfilled.

To the participating firms the main merit of the scheme lies in its efficacy as a pump-priming operation. The initial share of a development contract can justify recruiting a design team. By working alongside Ferranti's, that team can gain invaluable experience in appreciating the requirements, the special techniques and the appropriate methods of working together. The last phase, the one that really matters, is that in which this experience is used to exploit the potentialities of electronics in the firm's own sector of industry and its own markets. Such exploitation demands more than the technical designer's expertize. It calls for the appraisal of factors which lie outside his special function. Management has to consider the firm's productive resources; present and future market needs; the capital resources which might be required, and also the sources from which, and the conditions under which, these could be raised; the stresses which the finances, the employees, and the organization of the firm can bear. It has to assess the potentialities of the new techniques; the ability of the design team to evolve in time a product which can be manufactured; the abilities, too, of the draughtsmen, planning engineers, estimators, craftsmen, foremen, inspectors, salesmen and others. Wherever technical innovation is introduced as a 'resource', it affects every aspect of management and every manager throughout the firm; and in so doing it affects the relations of managers with one another.

It was found in the present case that, in the presence of rapid technical change and the strains which it imposes, two natural human reactions can be recognized and guarded against. One is the impulse to scurry back for safety to the 'mechanical' system, the authority of the chief and the book of rules. The other is to blame the personal defects and shortcomings of the individuals involved. Whether or not they contribute to the trouble, it has deeper causes.

These are negative prescriptions. Positive prescriptions must be differently interpreted in every

* Department of Scientific and Industrial Research. Problems of Progress in Industry No. 5: Human Problems of Innovation. Based on a study of some Scottish firms by Tom Burns and G. M. Stalker. Pp. 36. (London: H.M. Stationery Office, 1960.) 2s. 6d. net.

firm. The first and most general requirement is that management should constantly re-examine what the firm is supposed to be doing, with the conscious aim of adapting operating methods and the structure of managerial relationships to their present task. If the task of the firm can be carried out by a number of people, each with a set of responsibilities and correspondingly limited liabilities, each occupying a well-established place in a pyramid of authority, such a system is economical and effective and has the great advantage of imposing less wear and tear, stress and uncertainty on individuals. But when the firm is tackling new tasks, commercial or technical, this system of differentiated routine functions is not satisfactory. Delimitations must be made fluid, and responsibilities must be elastically shared. Every effort must be made to encourage the sense of the business as a whole, with objectives and goals common to all its members, rather than a complex of separate 'jobs'. The stronger this sense, the more recourse there should be to 'lateral' consultation, which should be recognized and facilitated and not regarded as a mere semi-legitimate supplement to the 'vertical' channels of command.

Putting these prescriptions into effect is partly a matter of organization and partly of establishing a code of good manners expressing—whatever the level of formality or informality—a spirit of co-operation and appreciation rather than the desire to score or to assert prestige. The firm should regard the continuous, deliberate re-casting of its structure, the establishment of 'organic' relationships, and the maintenance of a social climate in which these can flourish, as no less important a part of the innovating process than the building of laboratories and the recruitment of scientists and technologists.

CANCER RESEARCH IN THE U.S.S.R.

Pathogenesis and Immunology of Tumours

Edited by G. V. Vygodchikov. Translated from the Russian by R. Crawford. Pp. viii+258. (London and New York: Pergamon Press, 1959.) 80*s*. net.

THIS volume consists of a collection of papers in honour of Prof. L. A. Zilber's sixtieth birthday and is in no sense a text-book. Indeed it reads more like the annual report of the British Empire Cancer Campaign except that it does not cover so wide a field. It is unfortunate that the publishers did not give the date of its publication in the U.S.S.R., but the bibliography makes it virtually certain that most of the articles were written in 1953. Part one deals with the pathogenesis of tumours, parts two and three with immunological studies and there is a short section on investigations with electron microscopy.

A virus ætiology is widely favoured in the U.S.S.R. and one of the most interesting articles is that of Timofeevskii and Benevolenskaia on tissue culture studies. It is claimed that the mammary tumour milk agent can be propagated in cultures of mouse tissues as well as those of other species. The authors favour the idea that malignant transformation *in vitro* is due to viral activity. The milk agent itself did not produce malignant change in their hands but is said to stimulate growth. They produce some evidence that methyl cholanthrene and the milk agent act synergically to produce malignant change. The article is critically written, and readers must bear in mind that it is seven years old. A very scholarly review on the viruses of fowl leukoses by V. A. Parnes is curiously included in the next section.

Zilber and his school are best known for their serological work. A technique much used by them is to sensitize guinea pigs against a tumour, to de-sensitize with normal tissue or other pertinent antigen and then to challenge with the homologous antigen. Points of interest concern the ability to absorb rabbit papilloma virus with rabbit red cells, leaving a preparation free of virus but containing other tissue components. V. A. Artamonova has exploited this to demonstrate antigenic differences between papillomata and the resulting carcinomata. The same author claims to have isolated proteins from carcinomata that will neutralize the papilloma virus. There is a short and interesting article on the antigenic properties of human amyloid by V. A. Parnes. There are articles dealing with the antigenic properties of human tumours, and tumours from mice, rats and birds. Generally they show the presence of antigenic components present in neoplastic tissues that are absent from normal tissues; different types of neoplasm share some components but have some peculiar to themselves. In their article on the specific antigens of malignant tumours in man Gorodilova and Shershulskaia claim that specific antigens may sometimes be demonstrated on the red cells of patients with cancer of the lung, stomach, mammary gland and ovary.

Unless inbred strains can be used, claims to demonstrate tumour specific antigens tend to be suspect. One naturally wonders how far Lysenko might be responsible for the Russians being slower than some Western investigators to realize this. Probably he had no such influence. It appears that they simply failed to realize the impact of genetic research until they read T. S. Hauschka's review in *Cancer Research*, in 1952. It is quoted several times in this book and D. M. Levina directs attention to the desirability of further work with inbred strains. When I heard Prof. Silber speak in Amsterdam last June he emphasized the need to distinguish between transplantation antigens and tumour specific antigens. He has abandoned his anaphylactic technique in favour of gel diffusion methods. Work with inbred strains in Britain and the United States is now beginning to reveal tumour-specific antigens, so a great deal of the Russian work with other types of material may prove to be substantially correct. P. A. Gorer

EDUCATION IN SOCIOLOGY

The Social Purposes of Education

By K. G. Collier. (International Library of Sociology and Social Reconstruction.) Pp. xv+236. (London: Routledge and Kegan Paul, Ltd.; New York: Humanities Press, 1959.) 21*s*. net.

IT is not easy to decide at what level to consider this book. The title and the series in which it appears lead one to hope for a sustained and distinctive contribution to our thinking about the social

purposes of education. But the author seems to renounce this, saying that a comprehensive treatment would involve command of several academic disciplines and is probably beyond the compass of a single person. He says that he writes primarily for teachers and student teachers, and so we expect a book rather of simple exposition. Yet towards the end of his preface he re-states his aim as being "to articulate the relations between these disciplines". This is a task that would scarcely seem to be that of a near text-book. Then he immediately re-phrases this as being equivalent to a "search for criteria by which to judge educational methods". These two things, though related, are surely not the same. One begins to wonder what kind of book is intended.

The result is a work that has some good things in it, and that calls on a commendably wide background of reading, but that does not satisfy. The first three sections involve some economics, some sociology, some psychology and some discussion of 'values'. The last section, called "Educational Principles", is rather like a chapter from a sensibly progressive hand-book for teachers, and one feels that one is now at a different level of discourse. An attempt is made to link the earlier and the later sections, but in a very general way and without rigour.

Even if the purpose of the book were the modest one of starting students to think about the social purposes of education, one wonders how the author could attempt this without either more philosophical penetration or serious study of comparative education and societies. Philosophically, the book is conceived from within a very limited framework. There are many incidental signs of this, the oddest being the statement that science sprang from Christian sources, those of late medieval Christendom, a surely inadequate account of the history of scientific thinking in human history. Again, the good teacher's aim to show his pupils the truth as he sees it "without obliging them to choose his solution" is equated with the words of the Collect, "Make us love that which Thou does command". This is the kind of looseness which is allowed to pass too often in 'uplifting' writing about education. There is a great difference between commanding people to accept what you ordain (and to like it to boot) and leaving them free to make their own choice. There is the same lack of penetration in discussion of acceptance of the evils from which we suffer. These, we are told, may be accepted with a good grace when seen as coming from God, but are the soil of "envy, hatred and malice and all uncharitableness" when seen as the work of man. The author is thinking not of the material cause of suffering but of the frame of reference in which it is seen; but if he had thought of Islam and the "will of Allah" for a moment instead of his own beliefs he would have seen that this framework has a bearing on the readiness to remedy remediable suffering. When one thinks of the less-developed areas of the world, it seems terribly inadequate to say that the cause of suffering lies within oneself. Some, but indeed not all, suffering is an 'unalterable reality'.

This leads one to note the most surprising omission of all. How can one study the social purposes of education without considering different methods and systems of education in different social settings? Mr. Collier has a reference or two to such writers as Margaret Mead and Ruth Benedict, but one would have thought it indispensable to consider the role of the school in American social history or the social conception of education in the U.S.S.R. in our own times, or the social function of education in primitive societies and the impact of change on this, or Greek ideas about education seen in relation to society in fifth-century Greece; or at least some of these.

There is much material in this book that could have contributed either to a handbook for British teachers on the theme of the social setting of their work and the problems of 'socializing' the young through the school, or to a more sustained inquiry into the nature of the problem as such. But the book as it is is not quite one thing or the other, and it must be confessed that it leaves one disappointed.

H. L. Elvin

MATHEMATICS AND THE CONDUCTION OF HEAT IN SOLIDS

Conduction of Heat in Solids

By Prof. H. S. Carslaw and Prof. J. C. Jaeger. Second edition. Pp. x+510. (Oxford: Clarendon Press; London: Oxford University Press, 1959.) 84*s*. net.

THE theory covered by this book has a long history stretching back to the classical work of Fourier. It has undergone various stages of development covered by the subjects of Fourier series and integrals, Fourier–Bessel series, Laplace transforms and more recently integral transforms generally. The present work, the second edition, replacing the edition of 1947, gives a very comprehensive treatment of the theory and provides "as complete account as possible of the exact solutions and soluble problems of the subject". That the account is complete is very evident to the reader, who may be tempted into asking if there is much point in taking the analysis so far as is done in some cases.

The first 300 pages are devoted to the theory based on Fourier series. This includes the linear flow of heat in infinite and semi-infinite solids of various simple shapes. It concludes with an important new chapter on change of state, showing clearly how far it is possible to go with exact solutions and when recourse must be had to numerical methods. Melting and solidification are treated, and the practical importance of the results in problems such as ice formation, solidification of castings and the cooling of igneous rocks is pointed out.

Three chapters are given to the use of the Laplace transform method. These cover both linear flow and problems on the sphere and the cylinder, and emphasis is placed upon problems which may be solved more easily by this method than by the classical method. A practical problem which yields nicely to a theoretical treatment is the heating of a buried electric cable. Both short-circuit heating and constant-current heating are treated. The theory of heat regenerators and heat exchangers is also developed via the Laplace transform method, and there is a section on the theory of systems for automatic temperature control. It is perhaps a pity that more space is not devoted to these two topics, considering their great importance in chemical engineering. But the large number of references given will lead the reader to a more extended treatment.

The last two chapters are in the nature of surveys. They give accounts of the use of integral transforms

and the use of numerical methods. The former has been developed in recent years, notably by Sneddon and by Tranter, and a crucial property of the transformations is that in many cases they reduce the Laplace equation in two variables to an ordinary differential equation. The chapter on numerical methods is a short one showing how the equation of heat-flow may be converted approximately into a set of difference equations which may be solved numerically. There is also a brief section on the use of relaxation methods. It seems a pity that more space was not given to the use of numerical methods; for the limitations of exact solutions in practical problems are much in evidence throughout the book (for example, in the chapter on change of state), and a very powerful tool, namely the electronic computer, is now available for obtaining solutions to problems formerly beyond the range of the numerical analyst. In my opinion the analysis (in terms of symbols) of practical problems is sometimes carried too far, and it would almost certainly save much time in future if those concerned with heat-flow in practical problems were to make use of numerical methods at an earlier stage than has been customary in the past.

This book, more than ever, will continue to be the standard reference work in its field. It is to be noted that there are now more than 700 references. The beginner needing a guide to the vast literature on the subject, and the research worker who wishes to see how far exact analysis will take him in a particular case, will find it essential to consult "Carslaw and Jaeger".

L. S. Goddard

COGITO ERGO SUM

Symbolic Logic and Intelligent Machines

By Edmund C. Berkeley. Pp. v+203. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1959.) 52*s*. net.

Edmund Berkeley's previous book, "Giant Brains or Machines that Think", and its sequel are well-known introductions to the field of digital computers. The present book seeks to infuse life into the more recondite subject of mathematical logic.

Designers of computing systems differ in their regard for symbolic logic, and in particular Boolean algebra, as a practical tool, but nevertheless any but the merest tyro should have at least a working knowledge of the discipline.

As an introduction to Boolean algebra this book can be recommended, even though I join issue with Berkeley over the merits of Boole's own "Laws of Thought". This recommendation is possible because the latter book, although most readable, was written with an eye to the formal logic of the schools rather than as a design tool for switching circuits.

The first six chapters of Berkeley's book deal with formal logic and its application to switching. The treatment is basically that of Shannon, but the illustrative examples are of a light-hearted nature which will appeal to the non-specialist.

The first contact with 'intelligent' machines occurs in Chapter 7, where readers are invited to agree that intelligence is "the ability to learn from experience, to acquire and retain knowledge, and to respond quickly and appropriately to new situations, thus resulting in success in the performance of tasks". This definition could be questioned from a number of points of view, but, at the level at which the book is written, it is probably as good as any.

Unfortunately, the robot the actions of which satisfy this criterion of intelligence does not appear in subsequent pages of the book, and the reader may well doubt that a hall light, a syllogism machine, or a decimal adder justifies any claim that an intelligent machine exists. It is only fair to say that the author realizes this and, on page 97, attempts to clarify his position.

The remainder of the book is devoted first to an explanation of the way in which Shannon introduced the notion of time into switching algebra, which is very clearly written, and finally to the programming of Newton's method for evaluating a square root on a hypothetical digital computer *Zac*. This last chapter is a complete *non sequitur* and it is difficult to see why it was included.

In his preface the author invites comments and corrections. Unfortunately the number of misprints is too numerous for detailed mention, but it is impossible not to remark on the unsatisfactory nature of the circuit drawings. Surely it is not too much to expect the use of ruler and compasses and the adoption of standard notations for relay coils, and for rectifiers (for example, on Fig. 11-1); the same modicum of care might also have avoided such confusing situations as those shown in Fig. 14-6, where five change-over switches have both their sides connected to earth.

A. D. Booth

BIOCHEMISTRY AND MEDICINE

Biochemistry in Relation to Medicine

By C. W. Carter, Dr. R. V. Coxon, D. S. Parsons and Prof. R. H. S. Thompson. Third edition. Pp. xiii+628. (London and New York: Longmans, Green and Co., Ltd., 1959.) 50*s*. net.

The last edition of this well-known text-book was published seven years ago, and this new edition shows many changes. To begin with, the number of authors has increased from two to four, and the character of the book has been somewhat altered by the omission of the practical sections. The authors feel that universities and medical schools prefer to plan their practical classes in their own way. The original chapters have been extensively revised to bring them up to date, and there are some excellent new chapters dealing with the digestive secretions and intestinal absorption. In the light of increasing knowledge, much more stress is put upon the nature and mode of action of the endocrine secretions, and problems of electrolyte balance and renal function have been given more prominence. All this has led inevitably to a considerable increase in the size of the book, but to offset this it can be said that a good deal of the new material covers topics which, hitherto, have usually been regarded as falling more within the province of physiology. To biochemists, used to seeing so much of their subject included under the heading of physiology in the text-books, it is gratifying to find that, with advancing knowledge of hormone action and so on, the tables are now being turned.

This book is written primarily for students reading for a degree in biochemistry or physiology as well as for medical students, but needs of postgraduate workers have also been kept in mind. It follows that the book contains far more detail than most 2nd M.B. students can be expected to cover in the limited time

they have for biochemistry. Moreover, for them, the bibliography of more than fifty pages is quite unrealistic—a few selected references to reviews would be much less daunting. It was disappointing not to find any mention of the development of British anti-lewisite. Perhaps this was modesty on the part of one of the authors (R. H. S. T.), who was associated with this fine piece of war-time research of the Oxford School of Biochemistry; but the work is still of great interest, and it affords an excellent example of fundamental biochemical research which has led to valuable practical advances in medical treatment. Perhaps it might be included in future editions.

D. C. HARRISON

CARDIAC NECROSES

The Chemical Prevention of Cardiac Necroses

By Prof. Hans Selye. Pp. x+235. (New York: The Ronald Press Company, 1958.) 7.50 dollars.

THIS extraordinary monograph reports work done by an anonymous team of investigators (acknowledgments are confined to secretarial staff) following the discovery in 1957 that a cardiomyopathy with necroses could be induced in rats by the administration of cortico-steroids and certain electrolytes; this condition was called "electrolyte-steroid-cardiopathy with necroses", but abbreviated to E.S.C.N.

It had been known for some 14 years beforehand that steroids administered with sodium chloride could induce a hyalinizing myocarditis (without necrosis) associated with periarteritis nodosa and nephrosclerosis. The new discovery excited interest because of the prominence of myocardial necrosis and the lack of the associated lesions just mentioned. The nature of this new lesion suggested to Prof. Selye a possible relationship with myocardial necrosis induced by other means, such as potassium deficiency, administration of digitalis or vitamin D sterols, in experimental animals and occurring for reasons unknown in man.

The experiments reported here show that steroids with both gluco- and mineralo-corticoid activity are necessary for the production of this condition. Sodium chloride has no effect on its development, unless the animals are also subjected to 'stress', but sodium phosphate, sulphate, or perchlorate will induce it in the animal previously treated with steroids. Other electrolytes, it appears, have a protective quality when administered simultaneously; the most potent of these are potassium and magnesium chloride.

The bulk of the book is devoted to reporting these experiments giving the detailed results of the innumerable permutations of steroids, electrolytes, both aggravating and protective, and various unpleasant sounding forms of 'stress' applied to series of rats. The rest of the book is given to an introductory review of the historical background and to discussion of the possible hypotheses applicable to the observed results. There is finally a prophetic chapter discussing the future significance of these results in relation to the possible use of simple electrolytes to prevent myocardial necrosis in man.

The experimental study was certainly ambitious and thorough, but in some respects seems to have been over-elaborated. Prof. Selye sees great relevance in his observations on rats to certain naturally occurring conditions in man, but it is difficult to accept this. The discussion which deals with this aspect of the work and which, perhaps not surprisingly, rejects other hypotheses in favour of regarding the necrotizing cardiopathies "As 'Diseases of Adaptation' caused by some derailment of the General Adaptation Syndrome" lacks conviction and is often specious.

The following passage seems characteristic of the book: "Since the discovery of the E.S.C.N. less than a year ago, more than 30,000 rats were used in this Institute for experiments designed to clarify certain aspects of this subject. It is evident that the complete evaluation of this enormous mass of material poses almost insuperable problems and many of our present hypotheses will undoubtedly have to be abandoned in the light of future research". One wonders if the death of the 30,000 was worth while.

D. C. DEUCHAR

WATER RESOURCES

Ground Water Hydrology

By Prof. David Keith Todd. Pp. xii+336. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 86s. net.

THE increased demand for water in recent years, in the form of major water supply and irrigation schemes in all parts of the world, has accentuated the importance of the assessment and development of ground-water resources. This trend is by no means confined to under-developed countries. In England and Wales, for example, the estimated demand for water in 1965 is one and a quarter times that of 1955. In this sense, Prof. Todd's book is timely. Too long has ground-water been considered in a woolly, qualitative fashion by engineer and geologist. The need is for a quantitative assessment of ground-water resources and development potential. The recent application of the radioactive decay of tritium to the time dating of water is undoubtedly the key to quantitative work and marks the beginning of what may be a fruitful period of study.

This readable and well-presented text is addressed to a wide group—"students, specialists in hydraulics, geologists . . ." and is a comprehensive account of fundamentals, methods and problems in the field of ground-water hydrology. The reader is led very logically through the geology of occurrence of ground-water to the equations of seepage and flow into wells. While the subject-matter is familiar, the presentation is fresh and clear. It is inevitable that pure American practice is presented at times, as in the chapters on the construction of wells and the legal aspects of ground-water, but this is more than balanced by the American contributions in the form of "Basin Wide" development and artificial re-charge, for which work Prof. Todd is best known in Europe. Both these topics are new to text-books and they make a significant contribution to the value of the book.

The extent to which ground-water technology is indebted to the petroleum industry is shown by the two chapters on surface and sub-surface investigation techniques. Highly developed resistivity, seismic and magnetic methods are benefits derived from this wealthy relation.

The text is supported by well-chosen American data and an impressive array of some seven hundred references.

E. MILLER

Thyroid Radioiodine Uptake Measurement

A Standard System for Universal Intercalibration. By Dr. Marshall Brucer. Pp. ix+323. United States Atomic Energy Commission. (Washington, D.C.: Office of Technical Services, Department of Commerce, 1959.) 3.50 dollars.

THE measurement *in vivo* of the radioactive iodine content of the human thyroid is a deceptively simple procedure. Determinations of this type have been made with increasing frequency during the past twenty years, and are now widely used in the course of clinical diagnosis and radioisotope therapy, as well as in numerous investigations of thyroid function. It has long been known, however, that the calibration involved in such measurements depended critically upon the spectral sensitivity and shielding of the counting equipment used, as well as upon its geometrical relationship to the thyroid and the effects of scattering and absorption of radiation in the neck tissues.

In the course of discussions at Oak Ridge in 1953, and of subsequent inter-calibration measurements, it became clear that many laboratories and hospital departments were relying on inappropriate and quite inadequate techniques of calibration, and that gross systematic errors were being made in the estimation of the radioiodine content of the gland and therefore in the percentage uptake of any dose, since the *in vitro* measurements of the dose were not subject to corresponding discrepancies. The present publication by Dr. Marshall Brucer describes at length the effects upon the observed counting-rate of the counter shielding and collimation, the counter type and spectral sensitivity, the thyroid position, the scattering and absorption of radiation by body tissues, and the body content of radioiodine at the time of the measurement.

The book gives the text of a series of lectures on uptake measurements, and preserves their bulk and narrative character, with numerous explanatory diagrams and a non-mathematical form, and without any attempt to achieve a compact or formal analysis which would in any case be awkward in so practical and applied a problem. The material discussed will be of considerable value to those concerned with similar *in vivo* measurements and whose methods have not been subjected to detailed examination of this type.

E. E. Pochin

The Metabolism of Sulphur Compounds

By Leslie Young and George A. Maw. Pp. 180. (London: Methuen and Co., Ltd., 1958.) 16*s*.

THIS small book, one of the Methuen "Monographs on Biochemical Subjects", succeeds admirably in its object of giving a general survey of the metabolism of sulphur-containing substances. It directs attention to the great diversity of sulphur compounds in Nature, but deals, from the metabolic aspect, with many substances which have not been found in living organisms in addition to those of natural occurrence. The reader cannot fail to note the uncertainties which still exist regarding the precise course of the most important metabolic processes, such as the desulphuration of cysteine, the oxidation of this substance to sulphate, its conversion to taurine and finally its synthesis in micro-organisms. The formation of thiosulphate is also imperfectly understood. It is perhaps significant of the way in which the study of sulphur metabolism has developed that the authors have virtually restricted themselves to higher animals and micro-organisms and that the latter are dealt with in a single chapter. Although the authors state that plants and micro-organisms are responsible for the greater part of the interconversion of sulphur compounds in Nature, practically nothing is said of sulphur metabolism in plants; several unusual compounds which occur in plants are nevertheless mentioned. The authors, experts on their subject, have covered, however, the metabolism of sulphur compounds in higher animals in the widest possible manner, and are to be congratulated on producing a critical, well-written, informative and thoroughly documented introductory text-book.

G. D. Greville

Health in Industry

By Donald Hunter. (Pelican Book A441.) Pp. 288+18 plates. (Harmondsworth, Middx.: Penguin Books, Ltd., 1959.) 4*s*.

THE history of occupational disease spreads over many years and, until comparatively recently, ailments like beat knee, 'stagmus', writer's cramp, grocer's itch and cotton-workers' throat were accepted as heavenly or other visitations about which little could be done. With the growth of the industrial revolution the number of diseases multiplied so much in factory, workshop and mine that few industrial workers were able to get through a life-time free from occupational disease.

Since the industrial revolution began in Britain, it was fitting that British doctors should first assume responsibility for the health of the workers. This interesting book by a senior physician to the London Hospital, and one who has had long experience in industrial medicine, describes the genesis of industrial medical services and the way they have developed. Rightly, the author emphasizes that in this field prevention is better than cure, and that responsibility for prevention rests not only upon doctors but also upon the Government, architects, management, trade unions and the workers they represent.

T. H. Hawkins

Fertilizers and Profitable Farming

By Dr. G. W. Cooke. Pp. xviii+122. (London: Crosby Lockwood and Son, Ltd., 1959.) 15*s*. net.

IN this small book Dr. G. W. Cooke, head of the Department of Chemistry at the Rothamsted Experimental Station, has presented the substance of a series of lectures given to farmers. It is a straightforward account of how commercial fertilizers can be used to the greatest economic advantage. This has now become a matter of major concern to most arable farmers, and, though much of it is a matter of common sense rather than applied science, experimental results obtained in research fields and laboratories have supplied valuable quantitative data on which generalized recommendations about amounts, composition and application of fertilizers to different crops can be based. Dr. Cooke has used such data to make recommendations for fertilizing the principal British arable crops and grassland, and points out what adjustments are required for different conditions of soil and climate. The book is packed with useful information, but is too short to cover adequately operations on which British farmers spend £90 million a year. It deserves a better index than it has been given.

G. V. Jacks

THE INLAND FISHERY RESEARCH STATION, SAGANA, KENYA

By Dr. VERNON D. van SOMEREN, M.B.E.
Ministry of Forest Development, Game and Fisheries, Kenya

IN the period of reconstruction immediately following the Second World War, it was realized that future fisheries development in the Colonies must be based on scientific research, and to this end various developmental grants were made both by Her Majesty's Government in Great Britain, and by Territorial Governments, to enable fishery research stations to be established in various parts of the world.

In East Africa, such grants were the origin of two interterritorial fishery research stations under the ægis of the East Africa High Commission ; one dealing with marine fisheries off the East African seaboard and based in Zanzibar (East African Marine Fisheries Research Organization), the other dealing with freshwater fisheries mainly in the great lakes of East Africa, and based in Jinja, Uganda (East African Fisheries Research Organization).

On a territorial basis, grants from the Kenya Government enabled the establishment of two small freshwater research stations in Kenya Colony. One of these, the River Research and Development Centre, was situated on the slopes of Mt. Kenya about twenty miles from Nyeri at an altitude of about 6,000 ft., and has already been described[1]. After six years work, mainly on trout fisheries[2], this station had to be evacuated in 1953 as a result of the Mau Mau disturbances ; it was re-opened again in 1956 as a trout rearing station only.

The other research station was started as a small fish culture farm, based at Sagana, some sixty miles north of Nairobi, at an altitude of less than 4,000 ft. Before any large-scale development could take place here, it also was evacuated as a result of Mau Mau activity. It was, however, possible to re-open it again in late 1955, and it has since been expanded and developed as the Inland Fishery Research Station of this Ministry. Funds were made available both from Kenya development grants, and more recently, in 1959, under the Colonial Development and Welfare Acts of the United Kingdom.

The Station now occupies an area of some 180 acres, ideally situated on the main Nairobi–Nanyuki road, adjacent to Sagana railway station, and is at present developed to the extent of 18 one-acre ponds, 7 half-acre ponds, 8 quarter-acre ponds, 3 four-acre dams, 1 two-acre dam and numerous small breeding and experimental ponds, all well served by interconnecting roads.

The principal buildings include some housing, offices, stores and a main laboratory consisting of three rooms, a library room, stores and aquarium room. This latter has incorporated in it a long running-water channel, fed by the main pond supply furrow, and fitted with an underwater observation chamber ; in this the observation of river fish can be carried out, and spawning behaviour studied on various types of artificial bottom. There are five large static aquaria, and numerous smaller tanks.

The ponds themselves are supplied by a gravity furrow taken from the Ragati River, which runs through the grounds of the Station, and is affluent on one boundary to the very much larger Tana River which drains eastern Kenya. Within two miles of the Station, there are large hydro-electric installations on the Tana, and others are being considered, which will be of considerable fishery interest.

Both the Tana and the Ragati in the vicinity of the Station have falls of up to 15 ft. in their course, and above and below these falls there is in both rivers a good selection of indigenous fish such as cyprinids, eels, siluroids, cichlids and mormyrids. In order to study the biology of these indigenous river fish, the Ragati, a few hundred yards from the laboratory, has been spanned by a concrete weir supporting a horizontal grid trap of novel design, which traps all fish running both up and down (Fig. 1).

Last year, with only intermittent operation for nine months, the downstream grid of this trap yielded a catch of 366 lb. of fish, of which 264 lb. were eels, of two Indian Ocean species ; and at this trap an intensive marking programme of migratory fish is in progress, which is already yielding much valuable information on movements in relation to water conditions, spawning biology and growth. The biology of all these river fish is very imperfectly known. A small elver trap of traditional pattern has been erected at the Ragati Falls, and has already given results of interest[15].

River-water temperature and height are recorded continuously by instrumentation ; velocity, turbidity, and conductivity once daily. On the adjacent Tana River, there are a number of small indigenous basket trap fisheries, which have already been studied[3] ; the twice-yearly flood régime of the two rivers is a subject of particular study, since the large indigenous fisheries farther downstream are entirely dependent on these, and the commercial potential of the Tana, in particular, is large.

The climatic conditions at Sagana on the Station are recorded twice daily from Stevenson screen measurements, sunshine recorder, anemometer, and evaporation pan data.

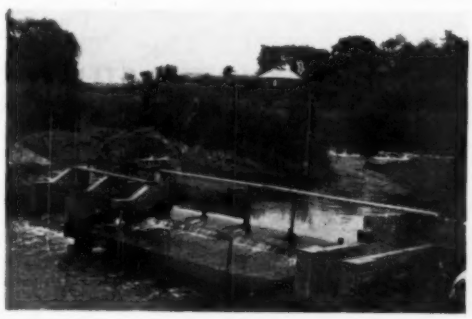

Fig. 1. Two-way fish trap on Ragati River. Upstream traps on left, horizontal grid downstream trap on right

The major part of the pond area is devoted to experimental cultural work, mainly on *Tilapia nigra*, an indigenous river cichlid; this species has proved particularly suitable for the monosex technique of culture developed formerly at this Station[4]. Easier, and more rapid, applications of this method have already been developed[5], since it has been shown that growth potential even after maturation is very marked; males can now be separated for fattening on the basis of breeding coloration only, and growth is very rapid even though they may already have bred.

Such sex-separation techniques, in addition to being an economic possibility, also offer a means of very precise population control in a pond, and hence are a most useful research tool in elucidating the factors which control basic growth, and hence final yield. Thus, monosex populations have already been used to determine the effect of depth and turbidity of water[6], sexual dimorphism in rate of growth, seasonal growth patterns[8], and effects of alterations of stocking density[9].

At the same time, attention is also being paid to different methods of cropping mixed breeding populations[10]. The value of all such experiments has been enhanced by tagging techniques[11] for recognition of individual and batches of fish, and the effect of such tagging determined[12].

At present, experiments are in progress on *Lebensraum* effects, further cropping methods, and a study of the scale structure changes found to be induced by monosex cultural procedures. Some twenty miles from Sagana, there is a large rice irrigation project, on which fish culture experiments are also in progress in co-operation with the Ministry of Agriculture, these being fertilization trials. To date, it would seem that ordinary farmyard manure and sulphate radicals (with or without nitrogen) increase final yields, though phosphates may have a depressing effect. No fertilization experiments are in progress at Sagana itself until the basic growth features of the ponds there have been finally determined, since any additives may change once and for all the basic composition of the pond.

Part of the Station is given over to the rearing and free distribution of fingerlings for elsewhere in the Colony. Other species under study are *T. mossambica*, *T. zillii*, a *Tilapia* from Zanzibar, and the new hybrid *T. zillii* × *T. nigra*, recently described[13].

Morphological, systematic and biological studies are also being made, such as that on the feeding mechanism of *T. nigra*[14]. River prawns, *Macrobrachium* spp., have recently become the subject of cultural study, since they could form a high-priced cash crop, but in general *T. nigra* still remains the main object of study, since in any such station confusion and mixing of fish can all too readily occur; the strictest precautions are taken over this, as also over the control of predators such as birds.

The Station is staffed by one resident research officer, one fishery officer, two African laboratory assistants and ancillary staff. There is a great need for more intensive hydrological, chemical and botanical work in the rivers and ponds, which cannot be undertaken with present staff limitations, though the laboratory is now well equipped for additional techniques.

The Station works in the closest co-operation with the interterritorial organization at Jinja, with which mutual interchanges of staff have been of great value, and the work is complementary, but in no way overlapping. The Nuffield Trust has recently awarded a two-year grant to support a research worker for certain observations on *Tilapia* biology to be carried out at both stations, but to date of writing (March 1960) no suitable candidate has yet been forthcoming.

Limited guest house facilities and working space are available at Sagana for visiting workers, though it is not possible to assist any such visits financially. With both river and pond facilities available, however, Sagana offers research opportunities almost unique in the overseas territories, in climatic conditions which are by no means unpleasant.

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A SYNOPTIC STUDY OF INFRA-RED RADIATION OVER THE UNITED STATES

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DURING the nights of May 26–30, 1959, twenty-five United States Weather Bureau stations co-operated in a synoptic study of infra-red radiation conditions across the United States. These twenty-five stations, each of which has the newer *AN/GMD-1* radiosonde telemetry equipment, sent aloft Black Ball flights instead of the regularly scheduled wind soundings at 0600 G.M.T. The Black Ball[1] is an instrument which measures, at any height, the total radiation incident on a roughly spherical surface; the quantity actually observed is the temperature, T_B, of a convection-shielded black absorber. This temperature is corrected for the effects of the thermal time constant and the residual convection to obtain

the radiation temperature, T_r, which is a measure of the total radiation reaching the instrument.

The experiment was planned to take place on the nights of May 26, 27 and 28, 1959, and the radiation instruments and modified radiosondes were distributed to the participating stations before these dates. Some difficulty was encountered with faulty battery supplies for the radiosondes, however, and not all stations were able to launch flights on these scheduled dates. Each of the twenty-five participating stations reported results from at least one successful flight, however, and the experiment must be considered a complete success. The results include those for which a satellite experiment was previously proposed.

There are numerous ways of synthesizing the results obtained. Since the Black Ball measures the radiation temperature, T_r, at any level in the atmosphere, it measures at very high levels a temperature which is related to the total outgoing energy from the Earth and the atmosphere below. This is so because at sufficiently high levels the infra-red radiation propagated downward is completely negligible, due to the extreme tenuousness of the atmosphere still overhead. At a sufficiently high level, if the outgoing power per unit area, dP/dA, is expressed as a function of an equivalent temperature of upward propagated radiation, $T\uparrow$, then the radiation temperature at this level is given by :

$$dP/dA = \sigma T\uparrow^4 = 2\sigma T_r^4 \qquad (1)$$

so the power-loss per unit area by the Earth to space can be readily determined from the observed high-level radiation temperatures.

In practice, at temperate latitudes, the radiation temperature is observed to remain constant with increasing altitude above about 100 mb., or 15 km. From the results obtained at the stations the flights of which reached high altitudes it is possible to draw isopleths of constant power per unit area lost to space by the Earth and the atmosphere below, as a function of geography. Plots of this kind for the three nights of the experiment are shown in Figs. 1, 2 and 3. The power-loss to space varies from 15·6 to 26·6 MW./cm.^{2} over regions which are small compared to the extent of the United States.

Several conclusions are immediately apparent from the observed results :

(1) Clouds have an overwhelming effect on the propagation of infra-red radiation through the atmosphere. The observed power-loss to space is not obviously dependent on the total atmospheric moisture or on the latitude, only weakly dependent on weather systems, and strongly dependent on cloud cover.

(2) The variation in power-loss to space over a relatively small geographical region on any one night is at least as large as the variation in the mean power-loss to space from equator to poles ; the same is true for any one location, comparing conditions from one night to the next.

(3) Since infra-red radiation is the only mechanism by which the Earth can lose to space the energy it gains from the solar illumination, the observed power-loss to space, which varies by a factor of 2 over

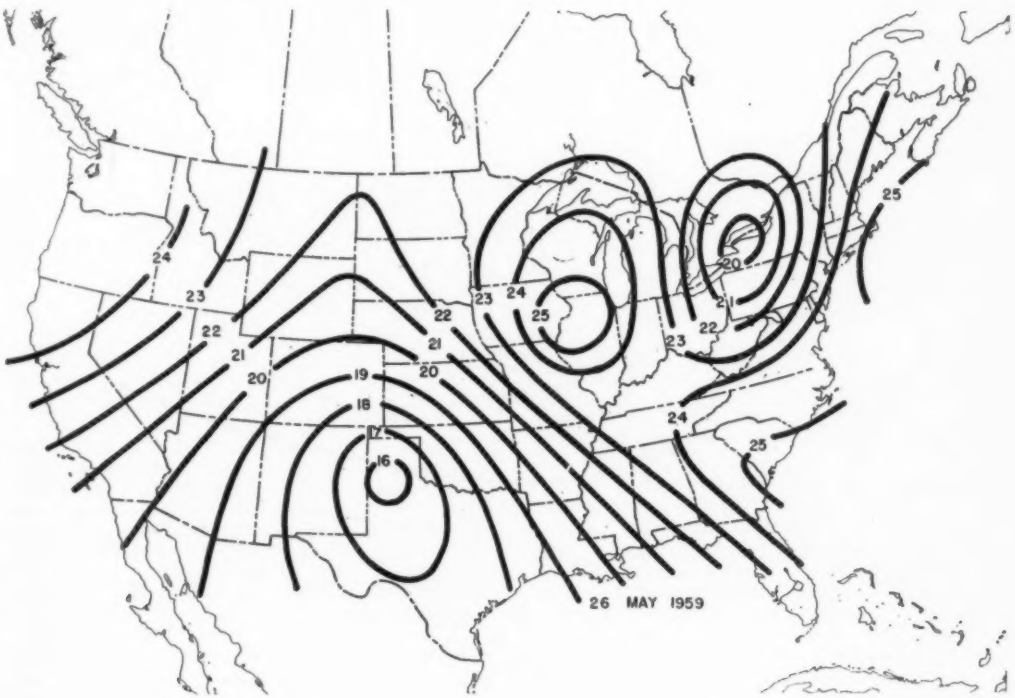

Fig. 1. Isopleths of constant power-loss to space per unit area (MW./cm.^{2}) observed over the United States on May 26, 1959

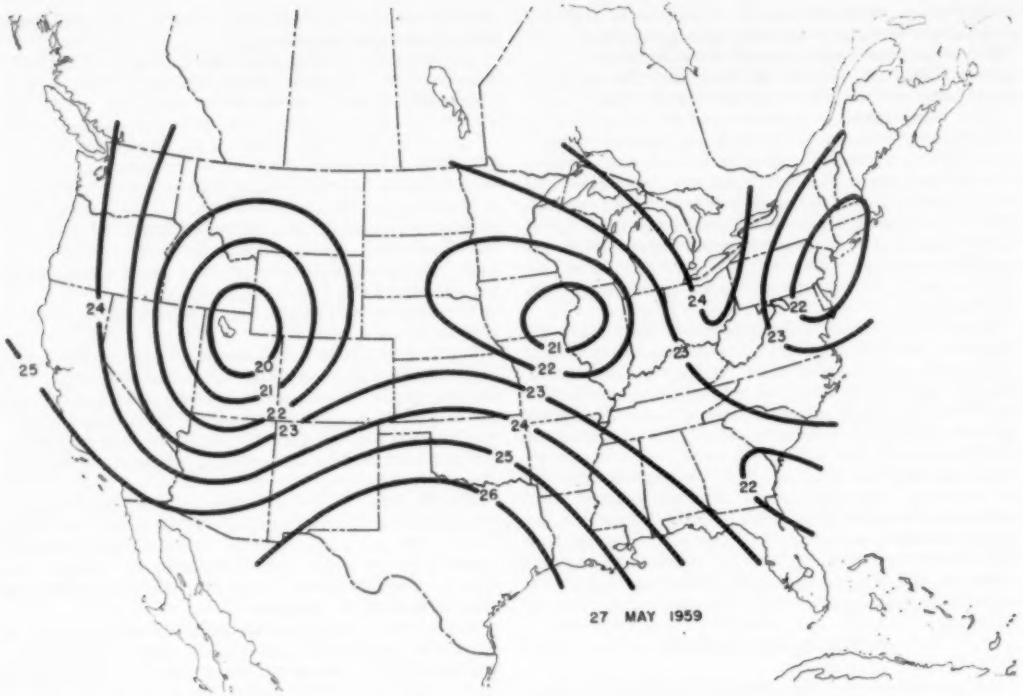

Fig. 2. Isopleths of constant power-loss to space per unit area (MW./cm.²) observed over the United States on May 27, 1959

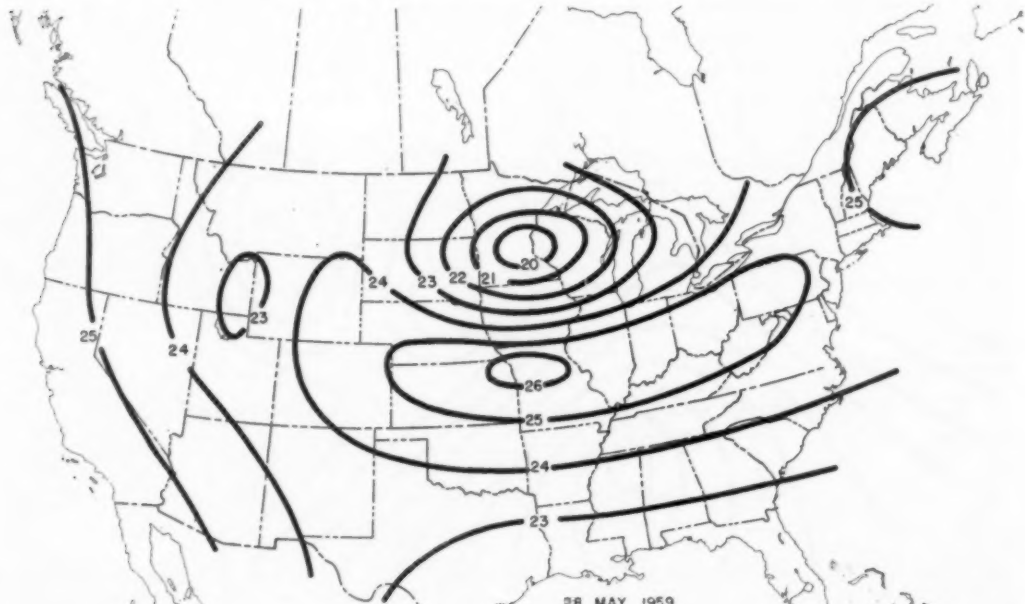

Fig. 3. Isopleths of constant power-loss to space per unit area (MW./cm.²) observed over the United States on May 28, 1959

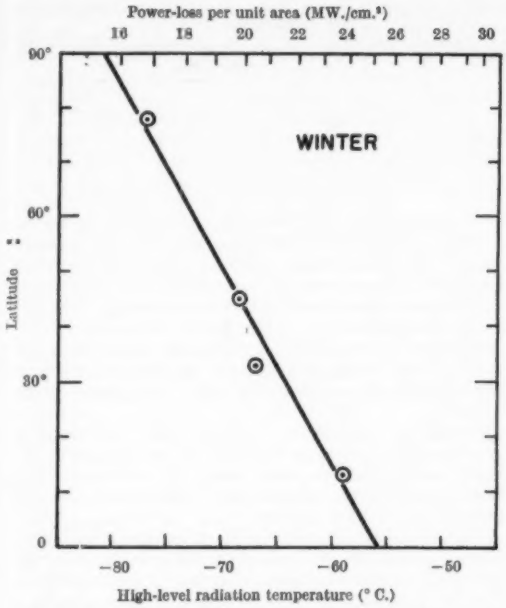

Fig. 4. Observed mean power-loss to space per unit area (MW./cm.²) as a function of latitude, given in terms of an equivalent radiation temperature. Each point is an average of at least eight individual soundings which reached high altitude

very small distances, must significantly affect the formation and propagation of weather systems.

The radiation 'lows' which are observed are found to be due mainly (perhaps exclusively) to clouds existing at high levels, 300–150 mb. These clouds, in some cases, are associated with the weakest cloud patterns observed by the standard synoptic network; in most cases, it is impossible even to track the movement of these cloud patterns from the surface reports.

During the three days covering the experiment, a weak front and trough separated the drier air over the south-western United States from that in the eastern part of the country. The difference in total atmospheric moisture does not appear to affect the observed radiation pattern at all significantly.

The mean winter-time power-loss to space, expressed in terms of the observed high-level radiation temperatures, is shown as a function of latitude in Fig. 4. The points shown are from results obtained at Taguac, Guam (13° N.), Holloman Air Force Base, New Mexico (33° N.), and Minneapolis, Minnesota (45° N.), in January, and McMurdo Sound, Antarctica (77° S.), in July. Each point represents an average of at least eight soundings. This number has been found to give a good average because of the large fluctuations of the high-level radiation temperature from day to day at any one location. The mean power-loss to space from these results varies from 15·6 to 25·2 MW./cm.² in going from the equator to a pole, a smaller variation than is observed on any one night across the United States. If one grants that the net radiation unbalance over latitude is responsible for the generation of weather systems and air motions, it must follow that the large radiation differences shown in Figs. 1, 2 and 3, occurring over small geographical regions, play an important part in controlling and modifying the weather systems existing there.

One further conclusion might immediately be drawn from the observations: the very nominal cost of flying the Black Ball as a standard synoptic instrument would be repaid many times over in detailed fundamental knowledge of the Earth's heat balance.

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NEW CLATHRATE COMPOUNDS OF THE INERT GASES

By J. G. WALLER

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A NUMBER of authors have claimed to have produced compounds of the inert gases. Thus, Crooke in 1906 postulated a reaction between molten zinc and helium gas[1]. Between 1927 and 1940 Damianovich published a large number of papers relating to compounds between inert gases and metals[2]. He claimed these compounds were formed when a glow discharge was struck between metal electrodes in an atmosphere of the inert gas at low pressure. Solid deposits were said to form around the electrodes, and these deposits were claimed to be compounds between the gas and the metal of the electrode. Boomer also claims to have formed a "tungsten helide" in the same way[3].

These processes for producing stable compounds of the inert gases have been re-examined. Discharges were passed between platinum or tungsten electrodes at about 5,000 V. in helium or argon, but no solid deposits containing appreciable amounts of the gases were obtained, although considerable sputtering of the metal of the electrodes occurred and some occlusion of gas could have taken place. Some experiments were conducted in which one electrode was a platinum gauze, with a third electrode just behind it. This third electrode was a coil of tungsten wire that could be heated. It was thought that inert-gas ions might be accelerated towards the gauze electrode, pass through it and form a compound on impact with the tungsten, either when hot or when cold. Again, no compounds were observed.

Other compounds have been claimed to exist between argon and boron trifluoride[4]. The evidence for their existence came from small differences in the freezing point of argon–boron trifluoride mixtures of different compositions. These differences in freezing point were small and were probably due to experimental errors. Later, other workers were unable to find any evidence for compound formation, under

identical conditions, between boron trifluoride and argon, krypton or xenon, or between xenon and trimethylboron, sulphur dioxide, hydrogen sulphide, ether or methanol[5].

Various other chemical compounds have been claimed from time to time but none has been substantiated, and it may be concluded that the inert gases are truly inert. However, one class of compounds of the inert gases does exist, although they can scarcely be called chemical compounds since the electrons of the inert gas atoms are not involved in the binding forces which are responsible for their existence. These are the clathrate compounds.

The name 'clathrate' was coined by Powell to describe the compounds between quinol and inert gases in which the inert gas atoms fill cavities in the crystal lattice of the quinol[6]. They are therefore a solution of gas in the solid matrix. A review of much of the work on clathrate compounds has recently been published[7]. Such compounds are formed by argon, krypton and xenon as well as by other gases, when quinol is crystallized very slowly from a suitable solvent under an atmosphere of the gas at an elevated pressure. Stable solids are obtained that, on warming, evolve the gas. Recently, use has been made of these compounds as a means of handling a radioactive isotope of krypton (krypton-85)[8].

The hydrates of argon, krypton and xenon were prepared soon after the gases themselves had been isolated. The original work was published by Villard in 1896 [9] and later confirmed by de Forcrand[10]. These workers showed that the inert gas hydrates conformed with hydrates of other gases in having a formula $X.5{\cdot}75H_2O$. More recent work by von Stackelberg has shown that the gas hydrates are, in fact, clathrate compounds[11–16]. Hydrates of krypton and xenon with heavy water have been prepared[17].

While the simple hydrates of the inert gases are known, little has been published on their double hydrates. This article describes some of these compounds.

Hydrates were made under elevated pressure in a stainless steel vessel or at atmospheric pressure in glass.

The high-pressure vessel was provided with a tube through which gas can be admitted under pressure and a side valve in the head of the vessel. By allowing gas to escape slowly from the side valve and maintaining the pressure in the vessel, gas was bubbled through the liquid in the vessel, thereby causing some agitation.

Argon at pressures up to 120 atm. was taken directly from a cylinder supply. For higher pressures it was fed into a 4,000 atm. compressor of the mercury piston type manufactured by Hart. Krypton and xenon were used at pressures up to 10 atm. from a cylinder supply and for higher pressures they were compressed in the Hart compressor.

Double hydrates were prepared using acetone, methylene dichloride, chloroform or carbon tetrachloride as the third component. After it had been shown that the compounds obtained were of the type described by von Stackelberg[12], having a formula $A.2B.17H_2O$ where A is the organic component and B the inert gas atom, liquid mixtures were used having the composition of 1 mole solvent to 17 moles water. Preparation of the acetone compounds was carried out by cooling in a bath at about − 30° C., while the other compounds were prepared in a cooling bath at between −5° and −10° C. To maintain a fine suspension of the halogenated methanes, about 0·01 per cent of sodium dodecylbenzene sulphonate was added to the water. The argon compounds were prepared at pressures between 200 and 400 atm., the krypton compounds at about 30 atm. and the xenon compounds at atmospheric pressure.

Table 1. Temperature at which Decomposition Pressure is One Atmosphere (° C.)

Inert gas	Organic liquid			
	Acetone	Methylene dichloride	Chloroform	Carbon tetrachloride
Argon	− 8·0	− 7·0	− 4·8	− 1·6
Krypton	− 5·0	+ 6·2	+ 9·0	+ 11·3
Xenon	+ 3·0	+ 8·6	+ 10·9	+ 13·7

The relative stabilities of the hydrates were determined by measuring the temperatures at which their dissociation pressures were one atmosphere (Table 1).

It will be seen from Table 1 that the stability increases from argon to krypton to xenon and for the third component in the sequence acetone (least stable), methylene dichloride, chloroform, carbon tetrachloride (most stable).

The xenon compounds were sufficiently stable to be formed simply by bubbling the gas through the appropriate solvent mixture cooled to 0° C. All the krypton compounds, except the acetone compound, could be obtained in the same way. However, the amount of gas taken up by the hydrates formed at atmospheric pressure was low and was usually less than 20 per cent of the theoretical amount. At higher pressures the gas content rose to about 100 per cent of the theoretical value.

In addition to the inert gas compounds, double hydrates of oxygen and of nitrogen with acetone and of nitrogen with carbon tetrachloride were prepared, but no reliable data on these compounds were obtained.

A number of other organic liquids were examined. Of these, *n*-butyl alcohol, methyl ethyl ketone, dimethylamine and ethylamine appeared to give double hydrates, none of them as stable even as the acetone compounds. Methyl, ethyl and propyl alcohols, glycol, glycerol, formaldehyde, acetic acid, ammonia, methylamine, hydrazine, hydroxylamine hydrochloride and chloral hydrate gave no evidence of double hydrate formation.

Attempts to make hydrates with benzene were also unsuccessful. This was a little surprising, since, according to the data given by von Stackelberg, the benzene molecule appears to fit the large cavities in the double hydrate lattice exactly[12]. Von Stackelberg mentions a double hydrate of benzene and hydrogen sulphide.

The crystallographic structure of some of the inert gas compounds was examined. The results showed the presence of a complex cubic hydrate, in agreement with the formula proposed by von Stackelberg, that is, one molecule of organic compound, two inert gas atoms and seventeen water molecules. The best pattern was obtained for the argon–acetone compound, which gave a cell dimension, $a = 17{\cdot}34$ Å. This value is close to those for hydrates of type II reported by von Stackelberg[12]. All the other compounds showed patterns for both ice and hydrate in varying proportions. Generally, the cell dimensions were in the range 17·3–17·5 Å.

The double hydrates of the inert gases have not been reported before. Most of the work on double

hydrates has been concerned with hydrogen sulphide as the gas. Carbon tetrachloride, chloroform and methylene dichloride have been used by earlier workers as double hydrate formers, but acetone has not been reported.

Von Stackelberg suggested criteria for the properties of organic compounds that are capable of hydrate formation[12]. In particular, they should not have strong van der Waals forces and, consequently, their boiling points should be less than 60° C.; furthermore, they should not exhibit strong hydrogen bonding and therefore should generally be insoluble in water. Acetone, of course, has a fairly low boiling point (56° C.) but it is soluble in water. Recently, von Stackelberg has described hydrates of water-soluble ethers, such as dimethyl ether and ethylene oxide[18]. He ascribed the solubility of these ethers in water to effects not associated with hydrogen bonding and therefore suggests that they fit in with his criteria for hydrate-forming molecules. However, Gordy's work on hydrogen bonding indicated that the ethers do exhibit some hydrogen bonding[19–21]. The proton-attracting power of acetone is, according to Gordy, about the same as that of dioxane, a cyclic ether, and less than that for diethyl ether. All show smaller proton-attracting power than the alcohols. It therefore seems that acetone can be classed with the ethers as an organic molecule that does not produce strong hydrogen bonds with water.

In conclusion, it may be said that a new series of double hydrates of the inert gases with acetone has been prepared. These compounds are of the same form as the double hydrates of chloroform or carbon tetrachloride with hydrogen sulphide. The inert gases also form double hydrates with carbon tetrachloride, chloroform and methylene dichloride.

I wish to acknowledge the assistance of Mr. D. Clark of the Royal Aircraft Establishment, Farnborough, Hants, in carrying out the crystallographic identification of the double hydrates.

Thanks are due to the directors of British Oxygen Research and Development, Ltd., for permission to publish this work.

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INTRASPECIFIC DIFFERENTIATION: BIOLOGICAL AND SOCIAL ASPECTS

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SIR JAMES GRAY has recently reminded us that it is quite 'proper' to seek rational pathways through palæontology to archæology and history; through sociological as well as biological evolution[1]; and it seems useful, in this connexion, to review the progressive differentiation among individuals of the same species.

Thus (1) slight ontogenetic differentiation will have occurred very early, between older and younger individuals. (2) Recombination, etc., gives genotypic differentiation among individuals of the same age. (3) Incipient speciation is also intraspecific; but not, of course, the follow-through of full speciation and adaptive radiation. (4) The individual of the diploid phase became different from that of the haploid; and it is fascinating that in several independent cases it was usually the diploid which then forged ahead, presumably due to the greater variability of its larger gene complement. (Within the multicellular individual, the differentiation among cells is well known; and most motile animals of more than 1 mm.^{3}—or more than one million cells—are now internally administered by a nervous system including some kind of 'brain'.) (5) Perhaps several times independently, anisogamy and oogamy arose, being a differentiation in function and structure among 'individuals' of the haploid phase.

Our own ancestors had already accumulated all the above forms of differentiation by 500 million years ago. Possibly by then, or not long after, they also became (6) dicœcious, as opposed to hermaphrodite, with the haploid dimorphism thrusting back round the life-cycle to affect the diploid stage as well. (The 'incompatibility' of many modern plants is a kindred extension of No. 5.) (7) Either before or after dicœcy, ontogenetic differentiation often becomes much pronounced: as in cestode, insect, amphibian and mammal.

The more successful among the larger land animals and plants of the past 100 million years—the mammals, birds and seed plants—have better developed 'care of young'. So have some Hymenoptera; and *Andrena*, *Osmia* and *Megachile*, for example, as well as *Halictus*, *Bombus* and *Apis*. One kind or other of this benign activity, on the part of the diploid parent, thrusts forward round the life-cycle to encompass both the haploid phase and the younger

stages of the next diploid individual as well. With dioecy, this commonly involves (8) a pronounced part-time differentiation of function between adult female and male. While exceptions are known, it is predominantly the egg-bearing adult which develops these benign parental activities which seem to be at the root of all fully developed social life[2]. It is nowadays clear that young birds and mammals learn some of their behaviour after birth, as cultural tradition. Thus in mammals, in any event, it is not uncommon for (9) the mother to be further differentiated functionally as providing the rudiments of the young's informal education and moral training[2].

Within the past million years, our ancestors have experienced several further types of differentiation as among the individuals of the same species, though two of these types arose in the Hymenoptera long before. Perhaps long after the first toolmaking, man experienced for the first time (10) a full-time differentiation of function between adult males and females. In surviving societies in the food-gathering stage, there is commonly a pronounced differentiation of this kind. For example, the larger game animals are hunted by men only; and certain domestic skills are practised by women only. This occupational differentiation between men and women may have been standard custom throughout post-glacial times, and for long before. It also occurs in some hymenoptera[3]. Some of these have domesticated certain animals and plants for food. *Homo sapiens* did, too, much later; but the effect of this on the social life of man[4] has been more profound than on any hymenopteran.

Some wasps, bees and ants achieved societies large enough to evoke (11) full-time occupational differentiation between individuals of the same sex. Indeed such intrasexual differentiation occurs in societies of *Halictus malachurus*, where the number of adult females is as low as about a dozen, though total individuals are greater. But in man, such full-time intrasexual specialization is not attested until much larger societies developed. Man achieved communities large enough for this change only after the inception of domestication, of agriculture. Thus in the ancient 'cities', full-time priests, kings and scribes arose as administrators—compare nerve cells arising in multicellular organisms—while other full-time male specialists who became differentiated included smiths, potters and merchants. The original threshold value of settlement size, for this differentiation to become conspicuous, seems to have been about 10 hectares, or 10^5 square metres, as during the Fourth Millenium B.C. in Halafian Iraq and Amratian Egypt[5]. The population of such settlements was something like $10^{3 \cdot 5}$. Much later, and apparently by independent and parallel social evolution, the same occupational differentiation among members of one sex took place in the New World too. It occurred in Peru in the First Millenium B.C., perhaps earlier than the Moche culture[6]. In man, there now soon arose (12) marked economic differentiation within one region. Thus in Third Millenium theocratic Egypt, the ratio of net equivalent income for sovereign and labourer was apparently sometimes about $10^3 : 1$; while it is only a little greater than $10^2 : 1$ in the United Kingdom to-day. Similarly, there arose (13) an intensified differentiation between richer and poorer regions. Compare Sumer and Greece in the Third Millenium B.C.; Greece and Britain in the First Millenium B.C.; and Britain and India since 1760[7].

With our increasing mastery of the environment, in recent centuries, (14) the number of different specialist occupations has again increased tremendously. But especially since 1870, two further forms of differentiation among human individuals may be discerned. While the child is still mainly left to the benign attentions of its mother, and father, for several years after weaning, it is then given ten years formal education by parent-substitutes. This is a further thrusting forward of parent-like activity, round the life-cycle. It proceeds at least to the age of 15 (United Kingdom); indeed to beyond the time when the scholar has become a sexually mature individual. Thus (15) in England and Wales to-day, nearly 2 per cent of gainfully employed persons have become differentiated in this manner, having become dedicated to the profession of education. As a consequence of this development of education, a further kind of differentiation can become much more intensified, (16) a social differentiation based on real differences in ability; which could greatly intensify the existing occupational and economic differentiation.

Most biological differentiations in man (Nos. 1, 2 and 4–8, above) are fixed or very firmly rooted. But when considering the development of society in the next few centuries, the sociological differentiations (Nos. 9–16), besides No. 3, are clearly to some extent capable of adjustment. The sociologist, after much more research, will need to consider which, among various attainable conditions, promotes greater social health besides mere survival. One cannot with certainty anticipate such findings. But it may be noted that in recent centuries some sociological de-differentiation[8] has in fact occurred. Thus (3), the incipient speciation of *H. sapiens*, due to reproductive isolation of populations in different regions, has been arrested and reversed; also (10) men and women are now very much less occupationally segregated; (11*a*) persons of different occupations now have much early education in common; indeed (11*b*) modern science itself was developed by persons who combined the abilities of craftsman and scribe; (12*a*) in many countries the institutions of slavery and feudal serfdom have disappeared, that is to say, the economic differentiation between 'free' and 'un-free' has lapsed; and (12*b*) the economic ratio between richest and poorest seems, in some advanced countries, now actually sometimes less than in ancient times.

Zoologically, man is often regarded as a relatively unspecialized animal—without horns, hooves or large canine teeth—and this is regarded as a factor contributing to his success. Some species of animal have become too specialized to survive environmental change, or to evolve further. Does the condition of less rigid or extreme differentiation among individuals in society correspond, in this respect, to being less specialized?

[1] Gray, J., *Advanc. Sci.*, **16**, 3 (1959).

[2] Huxley, J. S., "Evolutionary Ethics" (Oxford, 1943). Montagu, M. F. A., "The Direction of Human Development" (London, 1957).

[3] Imms, A. D., "Insect Natural History" (London, 1947).

[4] Pettersson, M., *Nature*, **184**, 481 (1959).

[5] Childe, V. G., "Social Evolution" (London, 1951). "What Happened in History" (Harmondsworth, 1954).

[6] Mason, J. A., "The Ancient Civilizations of Peru" (Harmondsworth, 1957).

[7] Blackett, P. M. S., *Advanc. Sci.*, **14**, 3 (1957). Wilson, H., "The World War on Poverty" (London, 1953).

[8] *Postscript.*—Compare the 'convergence' of de Chardin, P. T., "The Phenomenon of Man" (London, 1959).

OBITUARIES

Sir David Pye, C.B., F.R.S.

THE death of Sir David Pye, on February 22, at the age of seventy-three, at his home in Surrey, caused a deep sense of personal loss to his many friends and colleagues in university and government circles. He wore his eminence in science and engineering with a modesty and tolerance which engaged the warm affection of those who had the privilege of working with him. He was a scientist engineer who devoted much of his working life to the thermodynamics of the internal combustion engine and its design and construction. His wide knowledge and experience found their expression in "The Internal Combustion Engine", the standard English text-book and work of reference on the subject.

His heart was in university life. Educated at Tonbridge School and Trinity College, Cambridge, he began his career in 1909 as a lecturer in engineering at Oxford, and Fellow of New College, and ended it as Provost of University College, London, in 1951. He faced adverse circumstances and overcame formidable difficulties in both universities.

At Oxford, in the first decade of the century, engineering was fighting for its existence. Pye illuminated the scene in the course of his presidential address in 1952 to the Institution of Mechanical Engineers: ". . . There was one college where, for four years no student ever dared to risk the wrath of the Master, that was known to be impending for anyone who might be so rash as to suggest that he wished to take a degree in engineering science. Then, in 1913, we were astonished to receive a registration from the college in question. Vain jubilation! The wrath from heaven in the shape of the Master of the college, magnificent in full academic robes, was next morning at the doors of the engineering laboratory, demanding that his erring lamb should return to the classical fold. We never saw our potential student again".

One can almost see the quizzical look on Pye's face. He could not have been altogether surprised. Anger never came easily to him, but he must have resolved then and there to hang on. Throughout his life his invariable courtesy and reasonableness concealed a strong tenacity of purpose. Oxford engineers have good reason to be grateful to him.

The difficulties he faced at University College (the first institution in Great Britain to appoint a professor in engineering) were of an altogether different kind. He became Provost in 1943 of a bombed and dispersed College. It existed more in spirit than in fact, and when the War ended, the problem of satisfying the multitude of new and returning students called for a miracle. There was no miracle. There was only the diligent, steady, painstaking day-to-day effort of David Pye, tolerant as ever with those who wanted more than was humanly possible, and stimulating to those who were ready to share the real work. Before his period of office came to an end, the College had more than re-established itself as a great centre of learning and research. His anxieties were at times overwhelming, but his labours must, in the end, have given him a deep satisfaction.

Pye left Oxford in 1914 at the outbreak of war to become an experimental officer in the Royal Flying Corps. The then professor of engineering at Cambridge, Bertram Hopkinson, soon picked him out, and on demobilization in 1919 he went to Cambridge as Fellow of Trinity College and lecturer in engineering. There followed a most fruitful six years of teaching and research on volatile fuels pursued, largely during vacations, in collaboration with the late Sir Henry Tizard and Sir Harry Ricardo at his works at Shoreham.

His career in the Scientific Civil Service began in 1925 as deputy director of scientific research in the Air Ministry at the invitation of Mr. H. E. Wimperis, the first director. Wimperis and Pye laid the foundations of a vigorous and lively research department which was to prove its worth in the critical years ahead. The shadow of war was lengthening when Pye succeeded to the directorship in 1937, and again he faced a period of difficulty and anxiety. Air warfare and air defence loomed large in strategic importance, embracing many fields of science and engineering. New weapons, devices and equipment found their way into the Royal Air Force, and when Pye retired in 1943 he had carried the burden of the day, and what he set out to do was largely accomplished.

Pye disliked damping enthusiasms in others. His imagination gave him a real flair for uncovering other peoples' talents, and much of his life was spent in contriving circumstances favourable to their development. His interests and activities were wide, ranging from enthusiasm for mountaineering and rock climbing, to the love of music and musicians. Many young professionals and amateurs owe much to his warm encouragement.

He married in 1926 the daughter of C. Moore Kennedy, Virginia Frances, who nursed and comforted him throughout the long illness at the end of his life. Our sympathies go out to her, and to her two sons and daughter. BEN LOCKSPEISER

Prof. B. Gutenberg

WITH the death of Beno Gutenberg on January 25, seismology loses an outstanding figure. Throughout an academic career of nearly half a century he maintained an astonishingly large output of high-grade papers covering the whole range of seismology, especially in connexion with the propagation of seismic waves through the interior of the Earth. Indeed, it was truly remarked by Prof. Perry Byerly on the occasion of the presentation to Gutenberg of the Bowie Medal of the American Geophysical Union: "It is rare that anyone writes a paper in seismology without referring to him". Of his many achievements perhaps his most celebrated was the calculation in 1912 of the radius of the so-called liquid core of the Earth, usually referred to as the Oldham–Gutenberg core, the existence of which had been inferred by R. D. Oldham in 1906; considering the roughness of the existing data and the tentative methods then available this stands out as a veritable *tour de force*, and calculations by Jeffreys with a large body of precise data, embodying reflexions from the core that were not known when Gutenberg began his

researches, have shown that only a trifling correction is needed to Gutenberg's early result. It is somewhat invidious to attempt to single out any one topic from the vast array of subjects on which he worked in later years, but mention should be made of the important impact produced on geological and geophysical science by the long series of studies, made jointly with C. F. Richter, of the magnitude and distribution of earthquakes, a work that has given an enormous impetus to the study of the seismicity of the Earth.

Beno Gutenberg was born in Darmstadt on June 4, 1889. His training at the University of Göttingen afforded him the best possible ground-work at that time in the young science of seismology. Already well equipped with a wide and deep pre-university education, he attended mathematical lectures by Hilbert, Klein, Minkowski, Landau, Born, Wiechert and Weyl. In geophysics he worked on microseisms under Wiechert, who indeed covered in his lectures a wide range of geophysical studies. Jointly with Geiger, Gutenberg developed the Zöppritz method of using the amplitudes of seismic waves to study the internal structure of the Earth, and received his Ph.D. degree in 1911 at the age of twenty-two. After a further year of advanced study, during which he completed his paper on the Earth's core, and a year in the Army, Gutenberg was appointed assistant at the International Seismological Central Station at Strasbourg, which at that time was in Germany. In 1924 he became director of the Feldberg (Taunus) Seismic Observatory of the University of Frankfurt, at which University he later became a professor. During these years, in addition to the heavy load of observation, writing and teaching, he directed the family business inherited from his father.

In 1931 he was appointed professor of geophysics and meteorology in the California Institute of Technology, Pasadena ; here he played a notable part in the development of the Seismological Laboratory, of which he was director from 1947 until his retirement in 1957.

In later years honours fell thick upon him, both from European and from American academies. During 1951–54 he was president of the International Association of Seismology and Physics of the Earth's Interior.

Gutenberg was a kindly man, ever ready to help a fellow scientist and to indulge in a scientific *tête-à-tête*, and his accurate and retentive memory made him a pleasant and interesting companion. Visitors to Pasadena received a warm and hospitable welcome from Prof. and Mrs. Gutenberg ; theirs was indeed a happy and cultured home. Gutenberg had a large collection of records of classical music, and those visitors who shared his taste appreciated the privilege of the musical intimacy that he so freely extended. To the last his powers of original work remained unimpaired ; seismologists will mourn the loss not only of a great man but also of a valued friend.

R. Stoneley

Dr. Otto Schindler

Dr. Otto Schindler, who died suddenly on September 4 at Poitiers, while on a collecting expedition, had come to occupy a leading position among the small band of European ichthyologists.

He was born on December 1, 1906, and spent his childhood in Vienna and the Sudetenland. During 1925–30 he studied in Vienna under Versluys and gained his doctorate in 1930 with a thesis on fishery biology. For a short time he worked in the Vienna Museum ; but the greater part of his mature work was done at the Zoologische Staatssammlung at Munich, where he attained the rank of *Oberkonservator*.

At Vienna it fell to his lot to describe two species of small fishes collected by Dr. V. Pietschmann over Hawaiian reefs. Although no more than a couple of centimetres long and showing many larval characters, these fishes included ripe males and females. Dr. Schindler directed attention to their pædogenetic characters, but placed them in the genus *Hemirhamphus*. When later Giltay found one in New Guinea waters he formed other views on their relationships and created a genus *Schindleria* and family Schindleriidae for them. More recently, Gosline (1959) made of them a distinct suborder, relating them tentatively, as Giltay did, to the blennies. Schindler himself was stimulated by them to make a comparative investigation of the kidneys of larval marine fishes, for which he paid a special visit to the Plymouth Marine Laboratory to collect material.

Schindler's other fields of interest were the ecology of the freshwater fishes of the Austrian and Bavarian lakes and the fish-fauna of South America. He took part in two expeditions to the latter continent and studied the collections of the early expeditions in Vienna and London. His field book of German freshwater fishes, "Unserer Süsswasserfische" (1953 and 1959), was translated into English and edited in 1957 by Dr. P. A. Orkin.

As a result of Dr. Schindler's initiative and organization the German ichthyologists produced a quarterly "Ichthyologischer Schriftennachweis", a classified list of titles, by which they helped each other to keep abreast of current ichthyological publications. Without his leadership this and much else in German ichthyology come to an end. All who knew him miss a valued colleague and friend. Frau Dr. Schindler, a scholar in another field, is left to mourn him with their daughter and two sons, the eldest just of university age.

E. Trewavas

Dr. L. O. Kunkel

Louis Otto Kunkel, faculty member of the Rockefeller Institute during 1931–49, was actively conducting scientific research in the field of plant pathology at the Institute up to the time of his death on his farm at Newtown, Pa., on March 20.

Dr. Kunkel established the Division of Plant Pathology at the former Princeton, New Jersey, branch of the Rockefeller Institute in 1931 and influenced significantly the growth of knowledge concerning the relationship of viruses to plant diseases. Bringing to his research theoretical knowledge and practical experience in the United States and Hawaii, he conducted research which shed new light on the nature of the virus and also led to new understanding of disease in peaches and other fruits, cranberries, maize and carrots.

Dr. Kunkel helped to foster the work of his associate, Dr. Wendell M. Stanley, who, in conjunction with Dr. John H. Northrop, shared the Nobel Prize in chemistry in 1946 for crystallizing the tobacco mosaic virus. Dr. Kunkel, in administering his laboratory, gave his junior associates a free hand in investigating the cause, transmission, pathology,

treatment and prevention of a number of plant virus diseases of great economic importance and theoretical interest.

It was shown for the first time in his laboratory that several different yellows-type diseases (such as the virus disease of asters known as 'yellows') could be cured by heat-treating the plants in which they occur naturally or to which they may be transferred. Various virus diseases of the peach were cured in this manner as well as some virus diseases in cranberry, periwinkle, and the potato.

Dr. Kunkel and his associates discovered the transmission ability of leafhoppers in spreading virus disease, the ability to kill such infective activity by heat treatment, and the restoration of the infective ability to the insect. He charted out carefully the infective ability of various virus strains of such diseases as the tobacco mosaic virus or yellows-type, and demonstrated for the first time how a leafhopper infective for one strain was unable to pick up and transmit the other. He showed how a parasitic plant, the dodder, can transmit virus diseases from woody plants to herbaceous plants in which they are more easily studied. He also demonstrated that peach yellows, one of the oldest and best-known plant diseases, is transmitted by a leafhopper of a certain species. He demonstrated the same kind of transmitting factor for corn stunt, a yellows-type virus disease of maize.

Born in Mexico, Missouri, on May 7, 1884, Dr. Kunkel received the bachelor's and master's degrees from the University of Missouri, and the Ph.D. degree from Columbia University in 1914. He held a travelling fellowship in Europe, served as a pathologist in the Bureau of Plant Industry, U.S. Department of Agriculture, and started to study the virus diseases of plants.

Working with the Hawaiian Sugar Planters Association, he served as associate pathologist to study the problems of mosaic disease of sugar cane. He then became a staff member of the Boyce Thompson Institute in Yonkers, New York, in 1923 and gathered around him a group of young men trained in several fields of scientific investigation. At the Boyce Thompson Institute, Dr. Kunkel made important contributions to our knowledge of the mosaic diseases of tobacco, sugar cane and Indian corn as well as asters yellows.

He was a member of several scientific societies including the National Academy of Sciences, the Botanical Society of America and the American Philosophical Society.

NEWS and VIEWS

New Foreign Members of the Royal Society

THE following have been elected foreign members of the Royal Society: Prof. G. W. Beadle, chairman of the Division of Biology, California Institute of Technology, Pasadena, California, distinguished for his outstanding contributions to genetics; Prof. Ragnar A. Granit, professor of neurophysiology, Kungl. Karolinska Mediko-Kirurgiska Institutet, Stockholm, distinguished for his researches on the physiology of vision and neurophysiology; Prof. G. B. Kistiakowsky, professor of chemistry, Harvard University, Cambridge, Massachusetts, distinguished for his work in chemical kinetics of gaseous reactions, photochemistry, thermochemistry, and structure of polyatomic molecules; Academician L. D. Landau, professor of theoretical physics, S. I. Vavilov Institute of Physical Problems, Moscow, U.S.S.R., distinguished for his contributions to theoretical physics.

The Zoological Society of London: Nuffield Institute of Comparative Medicine

THE Nuffield Foundation has made a grant of £100,000 to the Zoological Society of London to found an Institute of Comparative Medicine, and to provide two senior research fellowships. In expressing its deep gratitude, the Council of the Society has asked that the name of Lord Nuffield be associated with the name of the Institute. The Society already has a modern animal hospital, and the new Institute will provide a much-needed opportunity to increase knowledge of disease in animals, and so to maintain the health of the Society's collections at an even higher degree of excellence than at present. Much unique material from the Society's collections and elsewhere is available for study, and full use can now be made of opportunities for research that have not been fully exploited in the past owing to the lack of the facilities and personnel. A Committee, including Sir Roy Cameron, Dr. E. Cotchin, Mr. R. Fiennes, Dr. R. E. Glover, Prof. A. Haddow, Prof. R. Hare, Dr. L. Harrison Matthews, Mr. J. N. Ritchie, Dr. J. G. Smith, Prof. G. Paling Wright and Sir Solly Zuckerman, has been appointed to advise the Council on the organization of the new Institute, the terms of reference of which are to study disease in all its comparative forms.

Mr. Richard Llewelyn Davies, director of the Nuffield Foundation Division for Architectural Studies, and professor elect of architecture in the University of London, will design the new building in accordance with the over-all plan for the Gardens that has been devised by Sir Hugh Casson in collaboration with Mr. F. A. Stengelhofen, the Society's resident architect. In planning the Institute, it is hoped that effect can be given to conclusions drawn from an exhaustive study of the laboratory designs for which the Nuffield Foundation has been responsible over the past few years.

The new Institute, which it is hoped will be in operation in about two years time, is to be built as part of a new block immediately west of the main offices. It will form the central part of the block, the east wing of which will provide a new meeting room for the Society. The western wing will be added at a later date and will house the Education Centre. It is proposed that the Institute itself will have a frontage of about 85 ft. and a depth of 50–60 ft., and will have a basement, ground floor, and two upper floors. The foundations will be constructed so that an additional floor can be added at a later date if required. The floor area, including the basement, will be about 18,200 sq. ft. Twelve laboratory units each of 300 ft. are planned, with offices, technicians' rooms, photographic rooms, workshops and stores. In addition there will be weighing and sterilizing rooms, a media kitchen, chromatography, balance and other specialized instrument rooms, hot and cold rooms, animal accommodation, seminar and common rooms.

Agricultural Research Council: Weed Research Organization

The Agricultural Research Council is setting up a new Weed Research Organization which will assume some of the present functions of the Council's Unit of Experimental Agronomy at the University of Oxford. The new Organization has been created for the purpose of extending the applied research which lies between the basic scientific investigations being carried out at the Unit and the introduction of new methods of weed control in agriculture and horticulture. To provide the facilities required to enable the Organization to carry out this work, the Council has acquired a farm near Oxford, where a laboratory and other buildings are to be provided. The director of the new Organization will be Dr. E. K. Woodford, who is at present assistant director, under Prof. G. E. Blackman, of the Council's Unit of Experimental Agronomy. The Organization will maintain close liaison with the Unit, which will continue its main purpose of fundamental research concerning the factors which determine the selective action of compounds toxic to plants.

Nuffield Foundation: Unit for the History of Scientific Ideas

The Nuffield Foundation has formed a Unit for the History of Scientific Ideas which will produce educational films and books under the direction of Prof. Stephen Toulmin, formerly professor of philosophy in the University of Leeds. A sum of £60,000 has been allocated for the Unit. The Foundation believes that a better public understanding of science would be assisted if discussion of the history of scientific ideas had a larger part in the educational curriculum and in intellectual life generally. A place is being made for the subject at some schools and universities; but there is not enough educational material available at levels suitable for sixth forms and undergraduates. The first aim of the Unit will be to produce a basic collection of teaching films and text-books for use in sixth forms and introductory university courses in the history and philosophy of science.

Before the Unit was conceived, the Nuffield Foundation supported the production by Prof. Toulmin and Miss Goodfield of a colour film "Earth and Sky", which has been well received by educationists. The first two films to be made by the Unit are likely to be on the theory of matter and evolution, and the Hutchinson Group are to publish a series of books under the general title "The Ancestry of Science" covering the same ground as the films. A series of monographs at a more advanced level is also to be published, and some books with colour illustrations for secondary modern schools are also envisaged.

The Textile Institute

In his presidential address to the Textile Institute at its fiftieth annual general meeting at Leicester on April 22, the Earl of Derby stressed the value of the Institute to the textile industry. This was shown by the way in which the Institute's activities had flourished and its membership been maintained in a period of reorganization when many mills had closed, and it was encouraging to note the interest employers' organizations were now showing in technological education. Management, he said, must be prepared to spend both time and money in making certain that the right number of young men of the proper outlook are encouraged to enter the industry, and trained when in it, or that they would be ready to guide the industry in a future when other countries have developed technical resources equal to those of Britain. This could not be achieved cheaply: the industry must be prepared to invest in men as well as in machinery and it was a matter of vital concern to the industry that a professional man should keep his knowledge up to date and contribute to the development of his technology by playing his full part as a member of the Textile Institute. Lord Derby referred particularly to the technological work undertaken by the Institute, for example, in the preparation of standard methods of test for publication by the British Standards Institution, in the Institute's own publications such as "Terms and Definitions", its *Transactions* and its *Abstracts*. Appealing for more generous support from the industry, he suggested that the income of the Institute could usefully be doubled.

The Wandering British Scientist

In a written answer to a question in the House of Commons on March 28 as to what steps were being taken to stop the gradual loss of scientific personnel from the United Kingdom to the United States, particularly in view of the number of scientists who had left the Jodrell Bank radiotelescope project, the Minister of Education, as representing the Minister for Science, said that the general problem of emigration of scientific personnel had been under consideration for some years by the Advisory Council on Scientific Policy. Since 1958 steps taken by the Civil Service Commission and the Atomic Energy Authority to recruit British scientists in America had met with some success.

Payment of Scientific Civil Services

State Service of April 1960 contains the annual report for 1959 of the Institution of Civil Servants, issued in readiness for the annual meeting of the Institution at Eastbourne during May 23–25. The year was marked by a 3·5 per cent pay supplement on salaries up to £2,000, the Coleraine Committee's recommendations for the higher Civil Service and their acceptance by the Government, and a 10 per cent increase in night subsistence allowance with the commencement of a review of all subsistence arrangements. The report regrets the apparent downward trend of the status of professional scientific and technical officers in the Atomic Energy Authority, also some steps which might indicate an intention to minimize the role of the Department of Scientific and Industrial Research in scientific research. The Government's attitude to salaries in general is criticized, as is the continued refusal to make any move towards counting unestablished service in full for superannuation purposes. The membership of the Institution on December 31, 1959, is given as 51,632, and the issue notes that the present general secretary will be retiring after the 1961 Conference. Reference is also made to the possibility that technical Civil Servants may take a day off simultaneously in view of their growing impatience at handling pay requests.

Apprenticeship Training in Britain

In reply to a question in the House of Commons on April 11, the Minister of Labour, Mr. E. Heath, said he is proposing to set up a small number of classes in Government training centres to provide first-year

apprenticeship training. This training would only be given to boys accepted as apprentices by firms, and preference would be given to boys from firms which had hitherto found it impracticable to undertake apprentice training or to increase their present number of apprentices. No charge would be made for the training provided, but employers participating in the scheme would be required to undertake to pay the wages of apprentices during the year and to continue the boys' training afterwards under the normal industrial arrangements. The usual provision for day release would apply during the year. The scheme, he said, has been approved as a whole by the British Employers' Confederation and the Trades Union Congress, and the establishment of classes in engineering has been agreed by employers and trade unions in that industry. Mr. Heath said he proposes to extend the scheme to other trades and he is already in touch with the building industry.

The first training places will be available early this summer at eight Government training centres, and he expects to set up classes at other centres later this year, making a total of about 300 training places. The scheme will not in itself make a large numerical contribution to the expansion of training for skilled occupations during the 'bulge' years and is intended primarily to demonstrate a pattern of training which should appeal particularly to the small firms with only limited opportunities for undertaking training themselves. In reply to further questions, the Minister confirmed that the course would be a full-time one for the whole year, except for the normal arrangements for day release. A leaflet has been prepared for distribution to all firms concerned within the range of the Government training centres where training is to be given. It is not a pre-apprenticeship scheme and is governed by normal industrial arrangements. As to expansion, Mr. Heath said that the response from the industries involved must be considered. The first centres are at Aintree, Birmingham, Bristol, Cardiff, Millington (Glasgow), Leeds, Letchworth and Long Eaton. A similar statement was made in the House of Lords on the same day.

Scientific Information News

With the second volume, the title of *Science Information News* issued by the U.S. National Science Foundation is changed to *Scientific Information Notes*, which is regarded as more descriptive of its contents. The purpose of the periodical remains unchanged, and No. 1, Vol. 2 (February–March 1960), includes a note on the work to be undertaken by the Association of Special Libraries and Information Bureaux in Britain on the comparative efficiency of four indexing systems with the aid of a grant from the National Science Foundation. The Foundation is also making a survey of the publication practices of American industrial corporations, including some 200 of the largest companies undertaking fundamental research, and the survey data will be processed and analysed by the Foundation's Office of Special Studies.

Press Publicity for Scientific and Technical Conferences

A concise, well-written "Guide to Press Arrangements for Scientific, Medical and Technical Conferences" has been prepared by the Association of British Science Writers, and is being distributed by the British Association for the Advancement of Science, 18 Adam Street, Adelphi, London, W.C.2. (Pp. 31, 2*s*.) Edited by Ronald Bedford, the pamphlet deals successively with the impact of the Press on the public and on business; general points such as what journalists expect, the functions of the press officer and the various types of conference; the varied types of press representatives who may be present, such as the news agency reporters, journalists from the national and the evening newspapers, radio and television reporters, and the representatives of technical journals, the local press, the foreign press and free-lance journalists. A section outlining the organization required follows, which centres on such details as the equipment of press rooms and the arrangement of press conferences and briefings. There is a section on press summaries and finally some suggestions are collected for the guidance of the press officer.

Manchester Public Libraries

The one hundred and seventh annual report of the Manchester Public Libraries Committee, covering the year ended March 31, 1959, records a continuing increased demand: issues from the lending libraries rose to 5,675,301 volumes, from the reference libraries to 1,226,183 volumes, and the total book stock is now 1,152,827 volumes (pp. 28 + 4 plates. Manchester: Manchester Public Libraries, 1960). Considerable work was carried out on the Great Hall, the Technical Library, the Commercial Library and the Central Lending Library but the increased seating in the reference library did little to diminish overcrowding. Seating in the Technical Library was more than doubled and the number of volumes on the open shelves was increased from less than 8,000 to more than 25,000, while a lending section was added. There was a pronounced increase in information work and inquiries, and 459 books were supplied to other libraries, mainly in the north-west of England, and 128 books were obtained from outside sources.

Scientific Techniques in the Conservation of Paintings

In his recent lecture to the Royal Society of Arts entitled "Scientific Methods in the Care of Works of Art", Mr. F. I. G. Rawlins, recently scientific adviser to the Trustees of the National Gallery, reviewed the advances that have been made in the application of scientific techniques in the conservation of paintings during the past twenty-five years. The basic problems, from the point of view of the scientist, are largely those of chemical physics, because the materials of painting are essentially of a colloidal nature, and the process of cleaning which involves the diffusion of solvents through films is itself a lesson in chemical physics. The physical techniques discussed were soft X-rays (that is to say, at about 10 kV.) which give improved results when thin paint-films are being examined, and infra-red photography, which may often reveal an image of what lies under discoloured varnish. On the chemical side, reference was made to improved methods for the preparation of paint cross-sections, and development in the National Gallery of a special reversed-phase system of chromatography as a method of analysis for paint media. The importance of fundamental research was emphasized. As illustrations of this kind of work, reference was made to experiments being carried out to develop picture varnishes having a longer life than the traditional varnish based on natural resins, and also the precise

action of solvents on paints and varnishes which is in principle fundamental to a proper understanding of the processes involved in the cleaning of pictures and other painted objects. Mr. Rawlins also pointed out that international co-operation in this field has substantially improved, as is exemplified by the increasing influence and activity of the International Council of Museums, the foundation (in 1950) of the International Institute for the Conservation of Historic and Artistic Works, and the recent formation of the New International Centre in Rome.

Fluoridation of Drinking Water

The attitude of different countries to fluoridation of water as a means of preventing dental caries has been described by Gerald H. Leatherman and J. A. Ellis, secretary-general and his assistant, respectively, of the Fédération Dentaire Internationale (*Health Educ. J.*, **17**, No. 3; 1959). The majority of health authorities throughout the world are in favour of fluoridation. They include: Austria, although a few State authorities are undecided; Canada; Great Britain, where the Government has gone on record through the Minister of Health approving fluoridation as a proved method of prevention; Greece; the East German Democratic Republic; Hong Kong; Republic of Ireland; New Zealand, where the Department of Health is campaigning for fluoridation and the Minister of Health has publicly stated his support of fluoridation, although the Government has made no pronouncement either for or against the measure; Norway; Spain; the United States; and Yugoslavia (Republic of Slovenia), where the political, as well as health authorities, are financially supporting fluoridation and propagating it.

In the main, the following countries support fluoridation: Australia, Belgium, Czechoslovakia, Northern Ireland, Italy, Switzerland, and the Union of South Africa. The following countries are undecided: Denmark, Egypt, Finland, France, Japan, Hungary, Netherlands, Sweden. Opposed to fluoridation are the German Federal Republic, where the health authorities consider the addition of fluorine as dangerous, as fluorine is only harmless in small quantities and there exists a possibility of overdosage as a result of human incompetence; Indonesia, where there are no experts to supervise fluoridation of drinking water and insufficient personnel to practise fluoridation by the topical application method, while only a few big cities have a central water supply; in Latin America as a whole, there appears to be an absence of initiative on the part of many health authorities, as well as the absence of any movement to stimulate the interest of the municipalities.

Biological Standardization of Drugs

The Research Defence Society, 11 Chandos Street, Cavendish Square, London, W.1, has issued a new pamphlet (No. 10, April 1960, pp. 6) entitled "The Use of Laboratory Animals in the Standardization of Drugs". This explains, by means of straightforward questions and answers, what is meant by standardization of drugs, why it is necessary, why animals must sometimes be used, and what legal control is imposed in tests of this kind.

Exhibit of Invertebrate Evolution

A striking exhibit entitled "These are Invertebrates" was opened at the Australian Museum in July 1959. It is 32 ft. long and 9 ft. high, and shows the main groups of invertebrate animals and their relationships to each other traced by a system of fluorescent plastic lines and lights which flash in sequence, some eight hundred light globes and ultra-violet light being used. Labels outline the characteristics of each major group and the scientific and popular names of the individual species are shown. A panel informs the visitor how to use the exhibit. Of the total of 215 species displayed, fifty-five are paintings and forty-three are models.

Photoperiodic Response of Some Tropical Plants

It was formerly thought that the small variation in day-length in the tropics could have no appreciable photoperiodic effect on native plants. This has now been refuted by Indian work on rice and other plants. E. Njoku of the Department of Botany, University College, Ibadan, Nigeria, has tested whether certain plants are sensitive to photoperiod when grown at Ibadan (latitude 7° 26′ N.) with a day-length varying from 11 hr. 41 min. in December to 12 hr. 33 min. in June (Njoku, E., "The Photoperiodic Response of Some Nigerian Plants", *J. West African Sci. Assoc.*, **4**, No. 2, 99; August 1958). The plants used fell into two main groups, day-neutral and short-day plants. No long-day plants were found. The results suggested that some plants had a critical day-length of less than 12 hr. Others flowered in 12 hr. but not 14-hr. days, indicating a critical day-length between 12 and 14 hr. A critical photoperiod of 12 hr. or less would make it possible for day-length to control flowering at the latitude of Ibadan.

Using day-lengths of 11½–12½ hr., that is, the extremes of day-length at Ibadan, it was shown that late okra (*Hibiscus esculentus*) and *Sphenostylis stenocarpa* showed a critical day-length of less than 12½ hr., and hence did not flower in the long 'summer' days at this latitude. Early okra and *Phaseolus lunatus*, on the other hand, flowered in both 11½-hr. and 12½-hr. days as well as in the natural day-length, but their response was quantitative in nature, the time to flowering being longer in the longer days. In order to test the effect of natural changes in day-length, successive monthly plantings were made in the field throughout the year. The results support the conclusions drawn from the experiments in which day-length was artificially controlled. Hence the photoperiodic response is of practical significance in the latitude of Ibadan. Plants of both groups grown under field conditions showed a marked shortening or lengthening of the vegetative period as the natural photoperiod decreased or increased. A difference of 15 min. may mean flowering or only vegetative growth.

Geology in the U.S.S.R.

An announcement of forthcoming publications issued by the Academy of Sciences of the U.S.S.R. lists 120 books on geology to be published in 1960, excluding periodicals, popular works, and reprints. Much the same order of output appeared last year from the State Publishing House for Geological Literature ("Gosgeoltekhizdat"); and taking into account the production of other agencies, it seems likely that the geological monographs and text-books published within the U.S.S.R. now number close on five hundred volumes annually. Since much of this literature is little known in the West, a special interest attaches to a paper by Prof. S. I. Tomkeieff on "The Progress of Geology in the U.S.S.R." (*Liverpool and Manchester Geological Journal*, **2**, 474; 1960).

This gives the first reasonably full account in English of the extensive geological work which has been conducted in the U.S.S.R., describing the organization of teaching and research and giving brief notes on progress in the various branches of the science. Although the scope of his short paper is immense, Prof. Tomkeieff brings to it a lifetime study of Russian literature, with the result that he opens new avenues to all geologists who are prepared to surmount the language barrier.

Magnetic Annealing

THE phenomenon of magnetic annealing, that is to say, the production of directional properties in a homogeneous alloy by allowing it to cool from a high temperature in the presence of a strong magnetic field, is well known from the early experiments of Bozorth and Dillinger on soft magnetic materials and those of Oliver and Shedden on hard ones. But the reasons for the establishment of such magnetic anisotropy have always been somewhat obscure. According to an announcement issued by the Bell Laboratories, recent experiments have thrown some light on the problem in the case of permalloy, which is in great demand in the form of fine tapes in electronic memory devices, where their switching times under suitable conditions are very short. The new experiments indicate that the magnetic annealing is not effective unless about 14–20 parts of oxygen per 10^6 are present in the permalloy, and there is little beneficial change in increasing the oxygen content beyond these limits. While the mechanism by which the oxygen acts is not clearly understood, it is suggested by Heidenreich, Burbank and Nesbitt that atoms are deposited on a crystal stacking plane at high temperatures, and so result in a displacement or dislocation of the next plane of atoms in the alloy. Whether this suggestion is correct or not, it certainly appears that close control of oxygen content is necessary.

A Commercial Thermoelectric Cold Box

IT is well known that many firms in Great Britain, the U.S.S.R. and the United States of America are working on the development of a practical form of thermoelectric refrigeration; also that the General Electric Co., Ltd., at their research laboratories at Wembley, have carried out extensive investigations on the fundamental properties of bismuth telluride and other semiconductor compounds. It is therefore not surprising to learn in a recent announcement that the Company has now produced what is claimed to be the world's first prototype model of a commercial design of thermoelectric cold box. The box is about 1 ft.^{3} in size and has a drop-down door. The Peltier effect is used for the production of cold, the cooling power of about 0·25 W. taking place at one junction of the thermocouple through which a direct current of 5–10 amp. is passed. The drop in temperature in the enclosure is 20–30 deg. The practical stage of development has been reached by the production of efficient semiconductor thermocouples and a form of construction which provides adequate thermal insulation between the hot and cold sides of the couple. The advantages of the system are lightness, the absence of moving or wearing parts, silent operation and the avoidance of chemical refrigerants. It can operate from a low-voltage battery d.c. supply, such as a motor-car battery, and the prototype cold box fits easily into the boot of a car.

The Wellcome Trust: Grants for Medical Research

THE Wellcome Trustees have announced that among the grants made during the half year ended February 29 were: £120,000 to King's College, University of London (Prof. J. T. Randall), towards the purchase of the lease of premises to house a Department of Biophysics; £70,000 to the University of Toronto (Prof. C. H. Best), to build and equip basically additional research accommodation in the Charles H. Best Institute; £15,000 to the Johns Hopkins Hospital, Baltimore (Prof. A. McGehee Harvey), to adapt premises in the Department of Medicine as a research laboratory for studies of the heart and blood vessels in man, especially by the method of X-ray cinematography; £30,000 to University College, London (Prof. P. B. Medawar), to build and furnish a research unit in cellular immunity as an annexe to the Department of Zoology; £8,000 to the University College of the West Indies, Jamaica (Prof. J. Waterlow), to purchase a mass spectrometer for use in the Medical Research Council's Tropical Metabolism Research Unit; and £2,500 per annum for up to five years, to Prof. A. St. G. Huggett, St. Mary's Hospital Medical School, London, to provide technical assistance and research expenses for work on the physiology of pre-natal growth.

Senior Research Fellowships of the U.S. Public Health Service

THE U.S. Public Health Service has announced that it will award twenty-one five-year senior research fellowships to scientists in eighteen universities and schools of medicine in thirteen States. Cost of the awards for the first year will amount to 260,562 dollars. No maximum stipend is set by the Public Health Service for these fellowships. Instead, each institution requests an amount for the stipend in accordance with its policy. The institution also receives 2,000 dollars a year towards research and travel expenses connected with the project. This is the fourth year of a five-year Federal programme to increase man-power for research in the pre-clinical sciences. The programme is administered by the Division of General Medical Sciences of the National Institutes of Health. The awards are designed principally for the partial support of promising young scientists sponsored by preclinical departments in the period between the completion of their postdoctoral research training and their eligibility for permanent academic appointments. In special circumstances, senior scientists may be awarded these fellowships to supply needed strength in preclinical science departments of schools of medicine, dentistry and public health.

First International Congress on Automatic Control

As the British member body of the International Federation of Automatic Control, the British Conference on Automation and Computation has, during the past year, selected 28 papers to form the British contribution on the subject of automatic control for presentation at the first International Congress on Automatic Control in Moscow during June 27–July 7. The arrangements for this Congress are being undertaken for the Federation by the U.S.S.R. National Committee for Automatic Control. The total number of papers to be presented is 282, and 20 countries are represented. The leader of the British delegation is Mr. John F. Coales of the

University of Cambridge. Further information can be obtained from the Honorary Secretary, Group *A*, the British Conference on Automation and Computation, c/o The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

Autonomics Division, National Physical Laboratory

The name of the Control Mechanisms and Electronics Division of the National Physical Laboratory is to be changed to the Autonomics Division. The Division is already well known in the field of automatic control and in pioneering digital computers. Such machines are deterministic in that their behaviour can be predicted from their design and their environment, and they can be designed only after a detailed mathematical analysis of the factors involved. By working closely with biologists in studying the methods which living physical systems use to achieve control, the newly named Division hopes to discover underlying principles on which machines that can improve their own performance can be built.

The Royal Institution

At the annual meeting of members of the Royal Institution held on May 2 the following officers were elected: *President*, Lord Brabazon of Tara; *Treasurer*, Mr. W. E. Schall; *Secretary*, Sir Harold Spencer Jones; *Managers*, Dr. T. E. Allibone, Dr. H. D. Anthony, Mr. E. R. Davies, Dr. A. G. Gaydon, Dr. H. Heywood, Brigadier H. E. Hopthrow, Mr. L. B. W. Jolley, Mr. P. H. Schwarzschild, Wing-Commander H. F. Tiarks and Prof. W. D. Wright; *Visitors*, Mr. A. D. R. Caroe, Mr. A. H. Ewen, Mr. G. J. Gollin, Mr. S. Rees Jones, Mr. W. C. Lister, Miss C. M. McDowell, Mrs. J. E. Milton, Mr. F. Allen Mitchell, Dr. A. A. Moss and Miss D. Sidebottom.

Royal Meteorological Society: Awards for 1959

The following awards were announced at the annual general meeting of the Royal Meteorological Society: *Buchan Prize for* 1955–59, Dr. R. J. Murgatroyd; *Hugh Robert Mill Medal and Prize for* 1959, Dr. B. J. Mason; *Darton Prizes*, (*a*) *Home Awards*, first prize to Dr. C. J. Adkins and second prize to Dr. J. A. Funk; (*b*) *Canadian Awards*, first prize jointly to Mr. R. H. Douglas and Dr. W. Hitschfeld, and second prize to Mr. D. K. A. Gillies.

University News: Cambridge

The Fellowship Electors have made the following appointments to Churchill College: Official fellowships: Dr. F. H. Hahn, fellow from October 1 and College lecturer in economics from October 1, 1961; Dr. D. J. Thouless, fellow and College lecturer in mathematics from October 1, 1961. Extraordinary fellowship: Dr. F. H. C. Crick, from October 1. Overseas fellowship: Prof. S. B. Treiman, associate professor of physics, Princeton University, from October 1.

London

The following appointments tenable at Westfield College have been announced: Dr. E. H. Bellamy, senior lecturer in the University of Glasgow, to the University chair of physics; Dr. E. H. Sondheimer, reader in applied mathematics at Queen Mary College, to the University chair of mathematics; Dr. G. E. Fogg, reader in botany at University College, London, to the University chair of botany.

Announcements

The Holweck Medal and Prize, given jointly by the Société Française de Physique and the Physical Society, has been awarded to J. Brossel, in recognition of his distinguished work on spectroscopy. The presentation will be made on May 11 in the Clarendon Laboratory, Oxford, after which M. Brossel will deliver an address (in English) on "Optical Detection of Nuclear Magnetic Resonance".

Dr. M. Tordoff, associate editor of the *Journal of the Textile Institute*, is to become editor of the *Journal of the Society of Dyers and Colourists*. He takes up his new appointment in August.

Applications are invited from members of the British Mycological Society and heads of departments for grants from the Cheesman and Pethybridge funds to enable students of mycology to attend the Spring or Autumn Foray, or the Plant Pathology Field Meeting. Grants will be made only to students who would otherwise be unable to attend these meetings on financial grounds. Applications should reach the secretary, Dr. J. G. Manners, Botany Department, The University, Southampton, not later than May 10.

The Department of Chemical Technology of the Bradford Institute of Technology is organizing a symposium on Co-ordination Compounds: their Chemistry and Applications during May 20–21. Further information can be obtained from Mr. G. J. Weston, Institute of Technology, Bradford.

An international colloquium on Sub-aquatic Medicine is to be held by the "Club Alpin Sous-Marin" at Cannes during June 15–19. Further information can be obtained from Dr. J. Ferrari, "Club Alpin Sous-Marin", 10 Place Commandant-Lamy, Cannes (A.-M.).

L'Association des Ingénieurs Electriciens sortis de l'Institut Electrotechnique Montefiore is to organize an international information day about nuclear energy in Liège on June 9. Further information can be obtained from Mr. A. Biron, the secretary of the Association, at 31 rue Saint-Gilles, Liège, Belgium.

The twenty-fourth congress of the International Association for the Protection of Industrial Property will be held in London during May 30–June 4, under the presidency of Sir John Hanbury-Williams, chairman of Courtaulds, Ltd. Further information can be obtained from the secretary of the Organizing Committee, H. C. Miller, 16 St. Martin's Le Grand, London, E.C.1.

A joint meeting of the Biochemical Society and the Société de Chimie Biologique in the Faculté de Pharmacie, Avenue de l'Observatoire, Paris 6e, during May 27–28, has been arranged. Further information can be obtained from Dr. W. J. Whelan, Lister Institute of Preventive Medicine, Chelsea Bridge Road, Chelsea, London, S.W.1.

W. H. Freeman and Co., Ltd., Hyde House, West Central Street, London, W.C.1, state that they are now the English publishers of Gilluly, Waters and Woodford "Principles of Geology" and of Sawyer "A Concrete Approach to Abstract Algebra", noted in *Nature* of April 2, pp. 57 and 69; the English prices are now 42*s*. and 7*s*. 6*d*., respectively.

POLYMERIC PROGRESS

FIVE hundred people attended a conference on Polymeric Progress held by the Plastics Institute during March 30–31. This figure was limited by the capacity of the William Beveridge Hall of the University of London, and many applications had to be refused. A speaker at the conference dinner pointed out the double meaning of the title, with its appropriate recognition that progress in polymer science and technology is so many-sided that it can be appropriately described as polymeric.

Following an introductory address by J. R. Whinfield, the conference took the form of eight papers, each of approximately forty-five minutes, followed by thirty minutes for questions and discussion. The diverse interests of members of the audience inhibited any detailed discussion and the question periods were for the most part used in clarifying and amplifying the papers. Each of these was an individual contribution, but for the purpose of this report they may be conveniently grouped.

The most dramatic of recent advances are concerned with the development of new methods of polymerization offering a high degree of control over the structure of a polymer. The effect of this on the physical properties of the polymer can be seen by reference to a few examples: (1) Polyethylene has become a well-known material in many household goods, characterized by toughness and flexibility, with a melting point of about 108° C.; the newer techniques give a much more rigid product, melting at 130° C. (2) Polymethyl methacrylate is familiar as the glass 'Perspex'; two new crystallizable forms have now been produced. (3) Naturally occurring polyisoprenes have long been known—natural rubber and gutta percha; essentially identical products have now been made synthetically, together with other crystallizable products.

The nature and the mechanisms of these new processes were the subject of a paper by G. Gee, in which several levels of structural control were recognized. The terms isotactic, syndiotactic and atactic, originally proposed by G. Natta, have now been widely adopted to indicate the sequence of stereochemical configuration along a polyvinyl chain —$(CH_2—CHX)_n$—. If the configuration of all the tertiary carbons are identical the polymer is isotactic; if configurations alternate regularly the polymer is syndiotactic; in an atactic polymer configurations are random. The configuration of each carbon is established as the unit is attached to the chain and it is clear that in general the two configurations will differ in probability: it is by control of these probabilities that the new procedures determine the product.

The simplest method of control uses low-temperature catalysts to favour the lower-energy configuration—generally syndiotactic. As the polymerization temperature is lowered, the degree of stereochemical regularity increases continuously and ultimately becomes sufficiently great for the polymer to crystallize. It has been suggested that polymer conformation in solution may sometimes be important: once a regular sequence is established (by chance) the polymer may tend to take up a regular conformation (for example, a helix) in which the same mode of addition is favoured.

The most remarkable of the new catalysts are metal alkyls or products derived from them. Especially noteworthy are the lithium alkyls and the Ziegler catalysts (typified by a combination of titanium trichloride and an aluminium alkyl). The three features which here seem important are highly polar metal–carbon bonds, metal atoms such as aluminium with a strong co-ordination tendency, and solid ionic surfaces. Almost all the most remarkable achievements in stereospecific polymerization so far reported have involved the use of heterogeneous catalysts. A particularly interesting system is found in the polymerization of propylene oxide by metal alkoxide catalysts, where the production of crystalline polymer is stimulated by partial hydrolysis of the alkoxide, giving condensed chain structures which reach their optimum efficiency just as they are on the verge of precipitation from solution.

The use of Ziegler catalysts was considered in more detail in the paper by G. Bier, who reported that the properties of nominally similar catalysts are highly dependent on the method of preparation. It is generally agreed that polymerization on these catalysts involves interpolation of successive molecules of monomer between metal (M) and polymer chain (P), which may be written formally:

$$M \ldots P + CH_2 : CHX \rightarrow M \ldots CH_2.CHX.P$$

Various processes can lead to removal of the polymer, which then ceases to grow and is replaced by a new chain, for example,

$$M \ldots CH_2.CHX.P \rightarrow M \ldots H + CH_2 : CX.P$$

Bier presented evidence of the preparation of catalysts in which such processes can be reduced to negligible proportions. In these circumstances it becomes possible to synthesize block copolymers $(CH_2CHX)_{n_1}(CH_2CHY)_{n_2}(CH_2CHX)_{n_3} \ldots$ by supplying two (or more) monomers successively to the catalyst. Copolymers of ethylene and propylene containing 10–20 blocks per chain have been made in this way and show physical properties generally quite different from those of either mixtures of the two polymers or random copolymers. A striking feature of these block copolymers is that all appear to be crystalline, though the crystal structure is unknown.

In the paper on "Acetal Polymers", W. H. Linton described another development in which a familiar monomer has been polymerized in new ways to produce a polymer the properties of which are such as to make it, from the engineer's point of view, a new material. The polymerization of formaldehyde is mentioned in elementary text-books, but stable high polymers have only recently been produced, and marketed as 'Delrin'. Linton described this material as an essentially linear polyoxymethylene with a density of 1·425 at room temperature and a crystal melting point of 180° C. It was stated to be usable continuously at 60–70° C. or intermittently at 100° C. Compared with older formaldehyde polymers, its high stability appears to be due in part to chemical treatment to remove terminal hydroxyl groups, and partly to the high degree of crystallinity consequent upon its very regular structure.

Another group of new-old materials was described by H. Schnell, in his paper on polycarbonates. Intensive earlier work on polyesters had failed to produce any polycarbonates of satisfactory stability and useful physical properties. Two factors which combined to open up this new field were the production of 'bisphenol *A*' $HO.C_6H_4.CMe_2.C_6H_4OH$ and its conversion to a polycarbonate by reaction with phosgene. It proved possible in this way to obtain polymers of high molecular weight which were crystalline and melted above 200° C. Subsequent work has led to the synthesis of many polymers of the general structure $—(OC_6H_4.X.C_6H_4O.CO)_n—$, where *X* may be $—CR_2—$, —O—, —S—, —SO—, $—SO_2—$. These are broadly similar in physical properties, an attractive feature being high impact strength. The polymers are all crystalline, generally melting above 200° C.; but a high degree of transparency shows that the crystallites must be small. Moreover, the fact that many of these materials are soluble in organic liquids at room temperature is surprising having regard to their high melting points.

The relation of melting point to chemical structure was discussed by H. C. Raine in his paper on polyolefins. Following the pioneer work of G. Natta, a range of 1-olefins have now been polymerized to crystalline polymers which are generally described as 'isotactic'. Raine emphasized that the ability of a polymer to crystallize is not a sufficient proof of 100 per cent stereochemical purity. In illustration he presented data on a large series of polypropylenes having melting points ranging from 110–180° C., correlated roughly but not exactly with the estimated percentage of crystallinity. For any discussion of the effect of monomer structure, one should clearly use the highest melting point which has been attained; but there remains some doubt as to whether data available at the present time are all reliable. Following the work of C. W. Bunn, Raine sought to interpret the data in terms of three factors: cohesive energy per unit length of chain, intrinsic chain stiffness and spatial symmetry.

Of these new polyolefins, only polypropylene has yet been developed commercially, but it may well prove that some others may have useful combinations of properties: the high melting points of polyolefins with bulky side groups are particularly noteworthy. The presence of these side groups in an isotactic polymer makes a planar zig-zag conformation of the chain sterically impossible. Crystal structure determinations on a series of polyolefins have shown helical structures to be characteristic. With this in mind, it might well have been expected that if vinyl cyclopropane could be polymerized isotactically, the polymer would show a similar structure. In his account of recent work by the polymer group at Brooklyn Polytechnic, M. Goodman reported that this does not appear to be the case. Vinyl *cyclo*propane has recently been synthesized, and polymerized with a Ziegler catalyst. Preliminary X-ray studies suggest that the crystal structure is a planar zig-zag.

The problem of polypeptide conformation in solution is dominated by the possibilities of hydrogen bonding. Goodman described work in progress on the synthesis and study of a series of short-chain polypeptides (2–12 peptide links). Optical rotation and rotary dispersion are being used as tools to study the competition between intermolecular association and formation of an α helix. In the latter, intramolecular hydrogen bonding occurs between links 1–5–9–13, 2–6–10–14, etc. End effects are naturally important in these short chains, and the interpretation of the results is not yet entirely clear.

Two papers remain to be mentioned: by H. M. Stanley, on "The Impact of Petrochemical Development on the Plastic Industry"; and by N. J. L. Megson on "High-temperature Resistant Materials". These approached the question of new polymers from opposite ends. The industrial development of a polymer is naturally highly dependent on economic consideration, and in these the cost and availability of monomers looms large. The remarkable progress of the petrochemical industry is well known, both in cheapening established products by opening up more direct and economical routes, and in making available on an industrial scale products formerly laboratory curiosities. In his survey of current trends, Stanley gave good grounds for the belief that if a polymer can be shown to be sufficiently worth while, the petrochemical industry will find a feasible route to the necessary monomer.

Megson's paper pointed the need for the development of polymers with new properties. The kinetic heating of high-velocity aircraft and rockets is already creating a demand for materials, both metallic and non-metallic, capable of performing more satisfactorily at higher temperatures than those hitherto encountered, and it is clear that the problems will become progressively worse as speeds rise. There are really two groups of problems, concerned respectively with thermal, oxidative and hydrolytic stability under very severe conditions; and with the physical properties of materials which encounter an exceptionally wide temperature range. Megson stressed the shortcomings of all known polymeric materials, but was naturally less able to suggest remedies. The overall problem is certainly too complex for any simple solution, and progress can only be foreseen over a broad and straggling front. General studies of new types of polymer will certainly have the high-temperature problem in view as an objective. At the same time, specific applications will require individual study to determine the best compromise between design and material. This is one of the areas where one may hope to find advances when the Plastics Institute holds its next conference on polymeric progress.

G. Gee

THE SCIENCE ASSOCIATION OF NIGERIA

The second annual conference of the Science Association of Nigeria was held in Zaria, Northern Nigeria, during December 15–18. This Association, affiliated to the wider organization of the West African Science Association, has only been in existence for one year. Its membership is recruited from all branches of the teaching profession, from government scientists and from industrial organizations.

The immense developments in Nigeria since the Second World War have given rise to a large increase in the numbers of scientific workers, both African and European. Yet the overall numbers are still

grossly inadequate for the country's need in an age of technological expansion. The Association was brought into being for the dual purpose of providing a forum for scientists working in the country and of informing the general public of the role which scientific work is playing in their lives. Already the Association has achieved considerable success. The quality of the papers and the discussions at the present meeting was extremely high, and it gave a picture of a general standard of work and achievement which would have been unthinkable not many years ago.

The most obvious immediate technological needs of Nigeria are in the agricultural and allied fields. It is not surprising, therefore, that a great deal of emphasis was laid on agricultural developments and of the relation of these developments to nutrition. But other subjects were not neglected. The vexed question of the biological effects of radiation—a real issue in Nigeria since the first mention of Sahara atom bomb tests—was dealt with in a most scholarly and authoritative manner. There were brief incursions into the realms of physiology and even of philosophy.

The importance of the meeting, though, really lay in that it brought together workers from many parts of Nigeria and from many fields of work. Physical and intellectual isolation are an ever-present danger in such a vast under-developed territory, and the real necessity is an interchange of ideas and points of view.

This meeting underlined a phenomenon of great significance certainly in Africa, probably also in other territories, namely, a re-orientation in the pattern of research. Before the War the tropics at the best were field stations visited by scientists from Europe, who collected their material for examination in properly equipped laboratories in Europe. To-day, Nigeria not merely has the laboratories—insufficient in number, perhaps, but still there—but also the scientific personnel to carry out the work. The opportunities here are immense, and the challenge is something which Europe cannot match. There is, after all, a fundamental absurdity, justified at the time they were created, in institutions of tropical research situated in England or indeed anywhere outside the tropics. This alone is a big development. Most of the original work carried out in Nigeria is, perforce, in applied subjects such as agriculture and medicine. Nevertheless, the third step towards scientific maturity has already been taken, for there is now a great deal of 'pure' research being carried out, particularly at the University College, Ibadan.

Science and technology in Nigeria are still young, but one feels that the plant is viable, that scientific activity will continue to grow, and that the nation as a whole will increasingly come to accept the new technologies as her best guarantee of future prosperity.

B. Hopkins

THE SMITHSONIAN INSTITUTION

THE annual report of the Smithsonian Institution for the year ended June 30, 1959, includes the Secretary's report, reports of branches of the Institution, the library and publications, and the financial report of the Executive Committee of the Board of Regents (Pp. x+243+10 plates. Smithsonian Publication No. 4389.) Washington, D.C.: Government Printing Office, 1959). Real progress continued to be made in transforming the museum displays into modern effective teaching exhibits and with 951,608 visitors at the National Gallery of Art, an estimated 4,055,673 at the National Zoological Park, the total number of visitors was 11,358,633. Some 260,000 specific inquiries were handled and 1,144,445 specimens were added to the National Museum, including four collections of Micronesian ethnological material, the entire herbarium of Goucher College, consisting of about 6,100 specimens, the legendary Hope diamond, a superb collection of Chinese jade carvings, more than 7,300 specimens of Carboniferous plants, the Monrós collection of more than 54,000 chrysomelid beetles, and many molluscs and marine invertebrates collected by the Bredin–Smithsonian Caribbean expedition; a collection of early handmade locks, bolts and decorative hardware, and dental instruments, furniture and equipment relating to the history of dentistry. Efforts to acquire early scientific apparatus used in colleges continued, and a group of scientific instruments used by Ira Remsen at Johns Hopkins University was acquired. Field work was conducted by members of the Museum staff in Central America, South America, the Caribbean and many parts of the United States.

Systematic researches by the Bureau of American Ethnology ranged from the River Basin Surveys, Arctic and Eskimo studies, the Seminole and Seneca Indians to archæological work at Russell Cave, Alabama, and progress is reported with the bibliography of the Arctic. The survey parties have now located 4,909 archæological sites in the River Basin Surveys and, of these, 1,017 have been recommended for excavation or limited testing. Work at the Astrophysical Observatory included solar physics, the development of two methods for determining the structure of non-grey stellar atmospheres, a study of atmospheric structure and its correlation with solar activity, studies of the secular acceleration of artificial satellites, meteoritic studies and the design of a telescope for use in space. The satellite-tracking programme continued and the Division of Radiation and Organisms continued its studies on the biochemical changes that occur during the development of the chloroplasts of higher plants. In a study of the lag phase of chlorophyll synthesis it has been shown that X-irradiation of 5–10 kr. can increase the lag phase in etiolated bean leaves, and radiant energy in the region 710–820 mμ significantly increases the frequency of chromosomal aberrations when used as a supplement to X-irradiation. Accessions totalling 341 specimens in 56 separate accessions to the Natural Air Museums included an early example of a German one-man helicopter, a *DM*-1 delta-winged glider of the Second World War, and many documents pertaining to pioneer rocketry research.

Accessions of 1,286 animals brought the total count at the National Zoological Park to 2,384; about 400 people visited the Canal-Zone Biological Area, including 54 scientists, students and observers using the station's facilities for special researches.

particularly in plant and insect studies, observation of wildlife and photography. The International Exchange Service received 1,129,476 packages, weighing 767,399 lb. of government, scientific and literary publications, and distributed 63 full and 43 partial sets of United States official publications; 85 copies of the Federal Register and 95 copies of the Congressional Record were also dispatched under the Interparliamentary Exchange of the Official Journal. The library received 52,669 publications during the year, bringing its holdings to 982,596 volumes, including 586,722 in the Smithsonian Deposit at the Library of Congress, and arranged 159 new exchanges. Eighty-one publications were issued during the year.

A CENTRAL INSTITUTE FOR SCIENTIFIC CINEMATOGRAPHY

TO find out what services a Central Institute for Scientific Cinematography could render to research and teaching in Great Britain, an inquiry has been carried out by the British Universities Film Council among a representative group of university teachers*.

A questionnaire relating to research was designed with the view of ascertaining, *inter alia*, whether by some method of sharing apparatus, existing facilities could be better used. The views of the research workers were as follows.

Research projects are undertaken with available resources in mind and unless cinematographic equipment already exists, or a grant to buy it is a possibility, cinematographic methods will not be used. Those departments with such equipment are using it most of the time and it is likely only to be available to visiting workers for short times; however, in the majority of instances visiting workers would be welcome, particularly to learn the methods in use. Many who use ciné equipment, and many more who do not do so at the moment, would welcome information concerning equipment available and the ways in which it can be applied to specific problems. This could be one of the functions of a Central Institute.

Another questionnaire was designed to determine how a Central Institute could assist teachers. The general reaction was that film at university level is properly used in showing the student moving phenomena which he cannot, for any reason, see at first hand; film should not be used to show observations or experiments which the student should make himself. Many films available, although they fulfil this criterion, are unsatisfactory for university work because they include theoretical material best dealt with in other ways.

University teachers want short films to illustrate particular points which can be best illustrated by cinematographic methods. This need involves an automatic 'push button' projector which has yet to be perfected and a source of supply of the illustrations.

Until such time as apparatus and illustrations are forthcoming, films will have to be used as at present. Many teachers are not aware of the films available on their subjects; the multiplicity of catalogues and sources of supply, each of which has few, if any, items of university standard adds to this confusion. A more centralized source of information is essential.

While the foundation of a Central Institute which had sections for the making of research films, the loan of equipment and secondment of specialized staff, an advisory service on research problems, the making of teaching films and a comprehensive information service on teaching films would appear one solution to these problems, it would seem that some of the current difficulties might also be solved in other ways. If there were greater recognition of the fact that, in many sciences, cinematographic methods have established themselves as a means of recording events for subsequent analysis, apparatus would be provided on a more liberal scale. Such apparatus requires skilled use, and short courses for training of technicians should be provided, perhaps in colleges of technology in various parts of Britain. If the research problems were tackled along these lines, it might be easier to obtain co-operation with other bodies interested in cinematographic methods in research and avoid the isolation which might result if a central institute for university research alone were set up.

The use of an existing organization for a comprehensive service of information of teaching film might well be considered. This would involve the organization in question receiving an earmarked grant from a government source, the grant being used for the collection, collation and dissemination of information on films available for instruction at university level.

Interest in the use of advanced cinematographic techniques is not confined to university departments; other bodies such as the Research Councils, various Ministries and industry are also concerned. If it proposed to set up an Institute which served all these interests, the universities would make full use of the facilities provided. It may be envisaged that universities would, in particular, be users of an advisory service on the application of cinematographic methods and on technical problems, any short instructional courses on methods whether for scientists or their technicians, and an information service on existing film which could be used for further research or for teaching purposes. University departments might be users of a service for the loan of specialized apparatus although they would wish to be free to apply for grants for the provision of apparatus for their exclusive use as previously. Here there may be a difference between the needs of pure and applied science departments; the latter frequently undertake research of an *ad hoc* nature for which the availability of apparatus on loan might have distinct advantages in that it would encourage a high technical standard in the research film made; much film produced in research in Britain, although adequate for the immediate purpose of the worker, is seen to be of poor quality when shown at scientific meetings, and is also inadequate teaching material.

* The Use of Film in Teaching and Research in British Universities 1959. (A Report of an investigation carried out in selected University Departments by a Sub-committee: G. E. H. Foxon, G. H. Bell and C. J. Duncan.) Pp. 24. (Newcastle upon Tyne: C. J. Duncan, Hon. Secretary, The Medical School, King's College, 1960.)

WEIGHT STANDARDS FOR MEN AND WOMEN

IN view of the importance of body-weight to health and longevity, the findings of the Build and Blood Pressure Study, 1959, conducted by the Society of Actuaries of the United States, are of major significance (Metropolitan Life Insurance Co. Statistical Bulletin, Vol. 40 (November–December 1959): New Weight Standards for Men and Women. Fathers are Younger. How Fatal Accidents Occur in the Home. Geographic Variations in Mortality by Cause. Pp. 12. New York: Metropolitan Life Insurance Company, 1959). The study not only contributes new data on average heights and weights according to age but also provides information from which new standards of desirable weight have been developed by the Statistical Bureau of the Metropolitan Life Insurance Co.

The new tables of average weights differ from those which were based on two similar studies of insured persons covering the periods 1885–1900 and 1909–27. For women the new average weights are consistently less than they were in the earlier studies, while for men they tend to be higher than before. Thus, at age 25, the average weight for women is generally 5 to 6 pounds less than that shown in the last study; at the age 35 it is from 2 to 4 pounds less, and at age 45 generally 2 to 3 pounds less. The decrease in average weights of women reflects chiefly their efforts to keep slim and, to some extent, the lighter weight of their clothes. Among men, the increase in average weight, compared with earlier studies, varies appreciably with height. The increase is greatest for short men, amounting to 5 pounds or more at most ages. For men of average height the increase is from 2 to 4 pounds, and for tall men from 1 to 3 pounds, the larger differences being found below the age of 45.

The average weights in the present study rise with advance in age among both men and women, but the pattern differs somewhat for the two sexes. Among men, the averages rise rapidly during the twenties and early thirties, but the rate of increase then slackens off and is very small between the forties and fifties. Among women, the increases in weight with age are fairly steady, but are most rapid between the mid-thirties and mid-forties. The lowest mortality generally occurs among people who are well below average weight. Even among young people, the advantage of a slight degree of over-weight is less pronounced than in earlier studies, and at best can now be considered only a temporary advantage. At the middle and older ages, the results of the new study not only show the disadvantage of over-weight, but also indicate that desirable weights, under current conditions, are somewhat lower than those shown in the tables prepared by the Metropolitan Life Insurance Co. in the early 1940's.

TEMPERATURE CHANGES IN THE ANTARCTIC ATMOSPHERE

DR. H. WEXLER, chief scientist of the U.S.–International Geophysical Year Programme, has published a valuable paper on the subject of seasonal and other temperature changes in the Antarctic atmosphere in the July 1959 issue of the *Quarterly Journal of the Royal Meteorological Society*. His results are based on observations made at U.S. and British International Geophysical Year stations in Antarctica and by the Scandinavian–British expedition to Maudheim during 1950–51.

The variation of temperature with height of the seasonal changes is strikingly different from that over temperate continents. The seasonal changes over Antarctica are greatest in the stratosphere (50–60 deg. C.), moderate at the surface (20–40 deg. C.), and least in the troposphere (10 deg. C.). The effect of the greater cooling of the stratosphere is to destroy for a long period the normal sharp inversion boundary of the tropopause between troposphere and stratosphere. During the sunlit part of the year the stratosphere is heated directly by absorption of solar radiation by the ozone which it contains, and it is cooled during the dark part by loss of heat by radiation from the ozone, carbon dioxide and water vapour, so that the stratospheric temperature falls quickly in autumn and rises very rapidly in spring. The fall of surface temperature is rapid in the autumn as the snow surface cools by radiation. Cloud in the winter causes remarkable increases in surface temperature since it is at a higher temperature than the surface itself and so heats the surface by radiation. An example of an increase of temperature by 30 deg. F. in 24 hr. at the South Pole when cirrus cloud came over is described in some detail. In the summer the snow surface is warmed by solar radiation despite its high albedo. The small temperature change in the troposphere is ascribed to the horizontal influx of warm air from over the surrounding ocean. Reasons are given as to why such advection does not reduce the temperature change in the stratosphere. In the troposphere, and at the surface, there is no marked minimum of temperature a month or so after the winter solstice as there is in temperate latitudes. In Antarctica the temperature drops sharply in autumn and then fluctuates about a low mean until the spring, when it rises sharply again.

The year to year temperature changes in Antarctica are as large as those in the interiors of a continent of the temperate zone, amounting to more than 10 deg. C. in the winter months. Thus, in August 1958 Byrd station in West Antarctica was 13 deg. C. colder than in August 1957.

By comparing recent observations on the Ross Ice Shelf with earlier ones as far back as those of Amundsen in 1911–12, Wexler is able to deduce the secular change of temperature. It is found that the mean annual temperature has risen by 2·6 deg. C. since 1911, which compares with a rise of 6·2 deg. C. at Spitsbergen over the same period.

EFFECT OF TEMPERATURE ON GROWTH IN WEIGHT AND TAIL-LENGTH OF INBRED AND HYBRID MICE

PHYSIOLOGICAL processes of acclimatization to high temperatures have been investigated for a number of organisms, but the effects of temperature on growth have received little attention. It is known, however, that growth in body-weight in the few subjects studied is greatly influenced by external temperature, and that there exists an inverse relationship between temperature and body size. It has also been shown for some organisms that buffering against external environment is better in first-generation hybrids than in inbreds. These considerations were kept in mind in recent experiments carried out by Prof. G. A. Harrison, Mr. R. J. Morton and Dr. J. S. Weiner*.

The material studied consisted of four inbred strains of mice and the six possible hybrids between them. Reciprocal crosses were included. It is shown that growth in body weight is partly determined by environmental temperature (70° F., 61° F. (control) and 90° F.). The weight of young heat-treated mice usually increases more rapidly than that of the controls, but at later ages the latter generally grow more rapidly. The magnitude and direction of the environmentally determined responses depend on the particular genotype.

Growth of F_1 hybrids in the two environments is more similar than the growth of their inbred parents, and differences in hybrid response are smaller than the corresponding inbred differences.

Hybrids in any one environment usually have a smaller variability than homozygotes—indicative of their greater homeostasis. One inbred resembled the hybrids in weight variance and weight responses, and the important conclusion emerges that inbreeding does not necessarily mean marked reduction in somatic fitness. The authors, however, do not put forward any explanation of this circumstance. It is perhaps possible that, as in maize, resistance to inbreeding may be genetically determined.

Growth in tail-length is also in part determined by environmental temperature; the higher the temperature the faster the growth-rate, and the longer the tail. The magnitude of the response again depends on genotype, though maternal environment plays some part. Hybrids have a smaller variability in both environments, and the totality of the evidence supports the hypothesis that the hybrids have a greater developmental flexibility than the inbreds.

S. C. Harland

* Phil. Trans. Roy. Soc. of London. Series B: Biological Sciences. No. 695, Vol. 242 (4 September, 1959): The Growth in Weight and Tail Length of Inbred and Hybrid Mice Reared at Two Different Temperatures. By Prof. G. A. Harrison, R. J. Morton and Dr. J. S. Weiner. Pp. 479–516. (London: Royal Society, 1959.) 12s.

SCIENTISTS AND ADMINISTRATION

THE description of the Laboratory of the Government Chemist in *State Service* (40, No. 3; March 1960) is a reminder that Government concern with scientific research is no new thing. Even earlier examples were the Royal Observatory (1675) and the Geological Survey (1835), and later the Patent Office (1852), the National Physical Laboratory (1903), the Medical Research Council (1913), the Department of Scientific and Industrial Research (1916) and the Agricultural Research Council (1916).

Quite apart from research to meet the needs of the Armed Services, Government research must be undertaken in order that the Executive may reach all its decisions on the best possible scientific advice, and in order that aspects of national life for which industry is either unable or unwilling to undertake responsibility shall not be neglected; aspects of such are fire, corrosion, afforestation, river pollution, coast erosion as well as problems in the building, transport and mechanical engineering fields. The new challenge of outer space is also throwing up problems calling for Government initiative in research and co-ordination.

The Institution of Professional Civil Servants believes that not only the scientific needs of government in the modern industrial State, but also the scientific needs of the State itself, can be adequately met only if the government is fully responsible for much research work. But the majority of the administrative class of the Civil Service appears to be proud of its scientific ignorance. This attitude is a grave handicap which could be partially overcome through a leavening of the Administrative Class by a deliberate policy of moving scientists into it.

One major difference between government research establishments and those in industry is that the scientists in the latter frequently have the opportunity to move into production and other fields of management.

In this respect the government service lags behind industry. The introduction of men with a scientific background into executive departments would be of benefit to both. Such scientists should undergo a period of administration to fit them to make a full contribution to the art.

When this type of movement occurs there should be no differentiation, either financially or otherwise, between the scientist-administrator and his colleagues trained in other disciplines. The transfer of scientists to administrative work should not be as if to a higher sphere of activity, but to introduce into administration scientists suitable for administrative duties. To ensure the maximum opportunity to develop and demonstrate administrative ability, much more use should be made of secondment to the headquarters offices of their department at all levels.

Apart from such administrative opportunities, the young scientist could obtain valuable experience in connexion with his own research work if he were encouraged to take an independent view and to express his opinions on his own work and the research programmes of his establishment. Research work is

essentially a team activity and can only benefit from free discussion among members of the team. Unhappily, in all too many government laboratories there is little or no consultation of this kind. He should also be encouraged to make outside contacts, both industrial and academic. Among outside activities which should be actively encouraged in government research establishments are those connected with the work of technical schools and colleges, particularly lecturing in their own field. These activities could be of value not only in broadening the experience and outlook of the research workers taking part in them but also, by reason of the contacts brought about, in helping the colleges to understand what is required of them in the changing fields of science and technology.

T. H. HAWKINS

QUANTITATIVE CYTOCHEMICAL OBSERVATIONS ON A SPECIFIC NUCLEOPROTEIN REACTION IN CELL NUCLEI

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AN application of micro-spectrophotometry to a specific protein cytochemical reaction is reported here, forming part of an attempt to understand the significance of a particular bonding observed in nucleoprotein in cell nuclei.

It has been shown[1] that a particular component of the nucleoprotein of cell nuclei can be distinguished cytochemically, by chromogenic reaction with a suitable diazonium hydroxide, after all other diazo-coupling groups in the specimen have been blocked by anhydrous benzoylation. The component responsible for this reaction was identified (in the case of chicken erythrocyte nuclei) as composed of histidine residues in the nucleoprotein. The reaction appears to locate a specific and rather labile bonding between this set of histidine residues in the protein and another set of groups in, or associated with, the nucleic acid.

The conditions for obtaining satisfactory micro-spectrophotometric measurements with this reaction have now been found to be as follows. Freeze-drying is the most suitable method, both on theoretical and empirical grounds. If the cytological preservation is inferior or variable, the staining is decreased or is non-uniform in distribution through the specimen. Sections or smears can be used; but the present results were all obtained on smears of disrupted fresh tissue. Errors due to the cutting of nuclei are thus avoided. It is of interest that freeze-substitution (in alcohols) virtually abolishes the reaction, both in smears and in sections. The smears (on cover-slips) were immediately quenched and frozen-dried in a version of the Edwards and Co. tissue dryer modified for this purpose and incorporating a nitrogen 'cold finger'; the temperature over the smear surface must be uniform (for example, $-50°$).

The dried smears are fixed in absolute ethanol and treated as previously described[1]. Moisture must be excluded until after benzoylation. Of the naphthols tested, *H* acid (1-amino-8-naphthol-3 : 6-disulphonic acid) gives the best results in the spectrophotometry. The stained, washed specimens are stored in immersion oil (Shillaber's) up to the moment of measurement.

The scanning, integrating micro-spectrophotometer of Deeley[2] was used, with a crushing condenser[3]. This apparatus has been shown to give precise measurements of the Feulgen stain in nuclei[4]. Of several mounting media tried, only glycerol gives technically adequate results, but a slow extraction of the stained component begins to occur after 1–2 days in glycerol.

Frog erythrocytes were used as standard test objects. A uni-modal distribution of the nuclear stain, with small spread (*S.E.* 2–4 per cent) is obtained. Variation between sets of cells in different specimens, prepared from the same blood sample and treated identically, was shown to be insignificant ($P > 0{\cdot}5$). Coupling with tetrazotized dianisidine (0·015 per cent) gives a plateau of maximum stain production for exposures from 14 to 30 min. at 2°. The coupling with *H* acid at the second diazo group shows a plateau over the range 5–15 min. exposure at 2° (followed by warming-up to room temperature for 20 min.). The length of the exposures to ethanol, or of storage in immersion oil prior to measurement, does not affect the intensity.

After a benzoylation period of up to 1 hr., unblocked cytoplasmic stain remains, but after longer periods the cytoplasm is fully blocked, and the nuclear intensity is constant for benzoylation times of 2–20 hr. This confirms the previous conclusion from visual examinations, that the component involved shows a qualitative, and not only a kinetic, difference from other cellular constituents in its behaviour towards benzoyl chloride.

Frozen-dried mouse tissues have been examined (Figs. 1 and 2), using the conditions established for maximum staining. The parenchymal cells of mouse

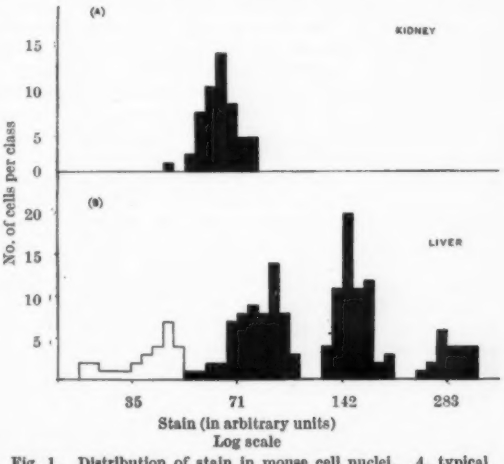

Fig. 1. Distribution of stain in mouse cell nuclei. *A*, typical mouse kidney sample; *B*, typical mouse liver sample; unshaded area, apparent non-parenchymal cells

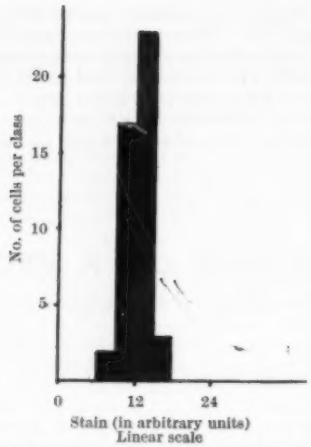

Fig. 2. Distribution of stain in typical sample of mouse sperm

liver show a tri-modal distribution, noticeably similar to that of deoxyribonucleic acid revealed by the Feulgen stain on this tissue[5]. The ratio of the mean values is fairly close to 1 : 2 : 4, and it is presumed that the three classes present correspond to the diploid, tetraploid and octaploid classes of rodent liver. However, an additional class is present here (unshaded area in Fig. 1) with a lower amount of stain. This separate, lowest class appears to consist of non-parenchymal liver cell nuclei (derived from connective tissue, blood vessels, bile ducts, etc.). Some of the larger non-parenchymal nuclei may well be included, however, in the lowest 'diploid parenchymal' class (and possibly *vice versa*), due to difficulties in cell recognition in the smears.

With mouse kidney (Fig. 1) a uni-modal distribution is obtained, again similar to the distribution of deoxyribonucleic acid in the tissue. However, the mean value for kidney does not quite coincide with the 'diploid' value for the stain in the liver of the same animal, and there is a highly significant variation between animals in this kidney value. Samples of kidney tubule cell nuclei from 8 adult mice, maintained under identical conditions (and fed *ad libitum*, stock diet 18, J. Rank Ltd.), each gave distributions similar in form to that shown in Fig. 1*A*, but the mean values ranged from 48·8 (*S.E.* 1·2) to 83·0 (*S.E.* 2·5) units, with a coefficient of variation (*C*) between animals of 18 per cent. There was no correlation with age between 8 weeks and 6 months. Differences between multiple samples from single animals were insignificant. Standard frog blood smears processed simultaneously with all mouse specimens gave constant results. It is concluded, therefore, that a real individual variation exists in the amount of this component in the nuclei of kidney tubule cells of these animals.

The 'diploid' values for mouse liver appear to lie in a narrower range (72·4, *S.E.* 4·7, to 82·6, *S.E.* 2·8, $C = 6$ per cent), although only 4 animals could be examined. (The present results assume that Beer's law is obeyed, but since the crushing method puts all the extinctions, as actually measured, into the same range, any possible errors are minimized.)

It is clear that the distribution of this nucleoprotein component shows both similarities to, and marked differences from, that of deoxyribonucleic acid. It closely follows deoxyribonucleic acid in intranuclear distribution[1], including location on the chromosomes in mitosis, and similarly in its correspondence with the ploidy classes in liver parenchymal cells ; but the value in sperm is much less than would be predicted on the deoxyribonucleic acid basis (Table 1). Even in somatic cells, however, the amount of this component is not determined by the deoxyribonucleic acid content alone, as can be seen from the results on liver non-parenchymal cells and on frog red cells (Table 1).

Since the liver ploidy classes normally correspond to classes of increasing cell size, a correlation with the latter variable might be suggested. Attention is directed to a correlation, at least for tissues where the required data are available, with the protein content of the nucleus (Table 1). The latter has been determined in mouse tissues on an individual cell basis by means of interferometry by Davies *et al.*[6] ; a fourth, lower class in mouse liver is similarly found. Since nuclei isolated in salt solution were used in those measurements the quantity involved is probably not the total nuclear protein, but a major (and less-soluble) fraction thereof, largely consisting of those proteins associated with the nucleic acid.

It seems likely that the observed variability of the stain in kidney tubule cells, which is in contrast to the constancy of their deoxyribonucleic acid content, is derived from unknown individual differences in physiological or metabolic states. The relative constancy of the stain in sperm heads and in frog erythrocytes, and its variability in kidney tubules, suggest that the component in question is concerned in cellular activity.

Table 1

Species	Cell type	No. of cells measured	Mean stain per nucleus	Relative stain per nucleus*	Total protein per nucleus* (relative)		Deoxyribonucleic acid (in 10^{-12} gm.) per nucleus†
Mouse (C57 strain, males)	Sperm	35	11·9	0·15	0·15‡		2·5
	Liver, class 1*A* ‖	39	36·6–41·7	0·50–0·51	0·44‡		5
	Liver, class 1	80	72·4–82·6	1·00	1·00‡	1·0§	5
	Liver, class 2	113	139–146	1·8–1·9	2·1‡	1·9§	10
	Liver, class 3	38	267–282	3·5–3·7	4·1‡	3·6§	20
	Kidney	405	48·8–83·0	0·63–1·1	*N.D.*		5
Frog (*Rana temporaria*, males)	Erythrocyte	503	57·4	0·75	*N.D.*	§	15

* Taking liver class 1 mean value as 1·00.
† From combination of data from refs. 5 and 9.
‡ Derived from data of Davies *et al.* (ref. 6), taking total protein as total dry mass of isolated nucleus, less deoxyribonucleic acid and less ribonucleic acid. Ribonucleic acid is taken (somatic cells) as ½ deoxyribonucleic acid (ref. 10), but this correction is, in any event, small.
§ For approximate comparison : data of Alfert *et al.* (ref. 11) on rat liver, by Millon micro-spectrophotometry.
‖ Lowest class, see text.
N.D. = not determined.

It is not, however, inferred that this histidine component is distributed uniformly throughout the nucleoprotein, but rather that the amounts of this component appear to be related to nuclear activities which in turn appear to be associated, perhaps indirectly, with the total nucleoprotein content. It is not yet possible to assign these histidine groups to an identifiable fraction of the nucleoprotein. However, it is of interest that recent X-ray diffraction studies[7] indicate that protein bridges form in the nucleoprotein of the nucleus on drying; these have properties, notably disruption by water, similar to those observed here. A possible interpretation, therefore, is that histidine side-chains (and perhaps others) are involved in these bridges. On this view, the present reaction locates specific sites of potential hydrogen-bonding, situated on certain protein surfaces in the deoxyribonucleic acid-protein complex and related to nuclear activities.

A detailed study of the method will appear elsewhere[8]. I should like to thank Prof. J. F. Danielli for his unfailing interest and encouragement; Prof. J. T. Randall and Dr. M. H. F. Wilkins, for the use of instrumental facilities in the Medical Research Council Biophysics Research Unit, King's College, and Dr. B. M. Richards for valuable help in connexion with the micro-spectrophotometry. Part of this work was aided by the British Empire Cancer Campaign and by the Nuffield Foundation.

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COMPARATIVE STUDIES OF YEASTS

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AN attempt is being made in this laboratory to develop improved methods for classifying yeasts. Present knowledge of the many different types of yeast and the methods for distinguishing between them is largely due to the work of the Delft school[1–4] under the influence of Kluyver[5]. This group of workers has developed the first thorough classification of both the sporing and non-spore-forming yeasts[4], the only other major work in any way comparable being that on the classification of the spore-forming yeasts by Kudriavzev[6].

The main divisions in the Dutch classification of yeasts[4] depend on their ability or inability to form spores and on morphology, although some biochemical characteristics are used chiefly for differentiating species[7]. Unfortunately, the factors which influence sporulation in yeasts (except for *Saccharomyces cerevisiae*) are scarcely understood. To make a yeast sporulate it may be necessary to culture it on a large number of alternative media; if, nevertheless, sporulation is not observed, it still does not follow that the yeast is incapable of forming spores. A further difficulty is that it is often impossible to define precisely the morphological criteria used. It is sometimes necessary, for example, to decide whether the buds of vegetative cells "arise on a more or less broad base"[7], whether they have formed pseudo- or 'true' mycelium, whether they are 'lemon-shaped', or whether the spores are "round or oval, reniform, bean- or sickle-shaped, Saturn- or hat-shaped, hemispherical or angular, fusiform or needle-shaped"[7].

The biochemical tests used by the Dutch school were in the first place mainly fermentation tests (that is, ability to produce gas, under fairly low but unknown oxygen tension, from glucose, galactose, sucrose, maltose and lactose[1–4]) and, secondly, growth tests using these sugars as sole sources of carbon[2–4]. In 1948, Wickerham[8] employed additional sugars, as well as glycosides, sugar alcohols, organic acids and other sources of carbon for growth tests, and he applied these new tests, to the classification of the genus *Hansenula*[9]. Kudriavzev[6] has also used many compounds for growth tests and this use of a large number of carbon sources has become popular among yeast taxonomists.

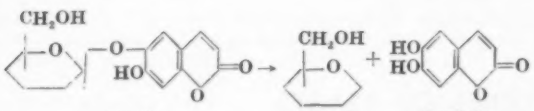
Although the widespread use of these growth tests has increased knowledge of the biochemical potentialities of many kinds of yeast, most of the tests are ill-understood and not carried out under well-defined conditions[10–15]. The Dutch workers have used auxanograms[2–4,10]: yeast cells are inoculated into a molten agar medium which contains all the growth requirements except one, such as a source of carbon; the medium is poured into a Petri dish; alternative carbon sources are placed on the agar surface and the presence or absence of growth observed. Kudriavzev's growth tests were carried out on slopes of medium, each containing a single carbon-source[6]. Wickerham[8,9] used defined liquid media, contained in unshaken tubes to which alternative carbon- or nitrogen- sources or vitamins were added, and the growth response was judged by eye (as for the auxanograms and for Kudriavzev's tests). It is, however, practicable to measure growth in liquid culture by photoelectric methods, using shaken T-tubes which provide uniform growth conditions for the tests[10,16].

As standard biochemical techniques have been introduced, it has become possible to develop a comparative study of yeasts which is based mainly on their biochemistry. In this work, imprecise and subjective morphological observations are avoided and there is no need to search for spores. Work towards this end is being carried out in this laboratory, and it is hoped to develop taxonomic procedures so

Table 1. The Growth of some Yeasts on certain Polyols

Yeast	Polyol					Reference
	Mannitol	Sorbitol	Galactitol	Ribitol	Erythritol	
Brettanomyces spp. { (9 strains)	−	+	−	+	−	20
Brettanomyces spp. { (2 strains)	−	+	−	−	−	20
Kloeckera apiculata (NCYC 328)	−	−	·	—	−	14
Saccharomyces cerevisiae (NCYC 77, 176 and 231)	−	−	·	—	−	14
Saccharomyces acidifaciens (CBS 685 and 739)	−	−	·	—	−	14
Saccharomyces bailii (CBS 680)	+	+	·	+	—	14
Saccharomyces marxianus (NCYC 111 and 243; CBS 712 and 745)	+	+	·	+	—	14

that each test will then reveal the presence or absence of a single enzyme, as suggested by Clarke[17]. For example, according to Wiles[18], *Candida guilliermondii* grows when the coumarin glycoside, æsculin, is the sole source of carbon, but *Candida krusei* does not. Is the reason for this difference that *C. krusei* lacks a suitable glycosidase or that it is poisoned by the æsculetin liberated by hydrolysis[13,14]? Is the same cause responsible for the comparable difference he described between *Hansenula anomala* and *Kloeckera*

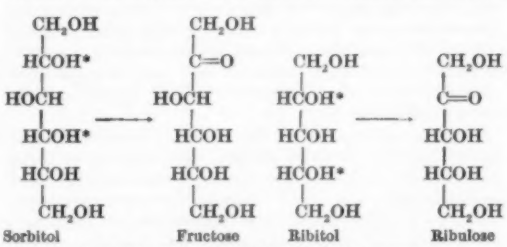


apiculata? As a further example, yeasts of the species *Saccharomyces cerevisiae* and *Saccharomyces acidifaciens* are unable to use exogenous intermediates of the tricarboxylic acid cycle (for example, malate, succinate, citrate) as sole sources of carbon for growth or respiration, while *Saccharomyces drosophilarum* and *Saccharomyces marxianus* are able to do so[15]. Since this distinction is now used by taxonomists[6,9], it is important to know whether it is due to differences in a major metabolic pathway or whether it reflects some difference of transport mechanism across the plasma-membrane[19], or sometimes the one and sometimes the other. A third example is provided by the work of Wickerham[3], who characterized nine out of fifteen species of *Hansenula* as unable to use erythritol as a sole source of carbon for growth. It is important taxonomically to be aware of three alternative possible reasons for this inability: failure of erythritol to penetrate the plasma-membrane; lack of a suitable dehydrogenase; or lack of a kinase capable of phosphorylating the erythrulose formed from the dehydrogenation of erythritol.

It has already been possible to throw a little light on some of these questions by working with cell-free extracts and comparing their behaviour with that of intact cells[14]. There are indications that yeasts contain a number of different β-glucosidases and that the phenolic aglycones liberated by their action are inhibitory not only to growth but also to the initial hydrolysis of the glycoside itself[13,14]. There is evidence of the occurrence of the tricarboxylic acid cycle both in yeasts that are capable of using exogenous intermediates of the cycle, and also in those that are not[15]. This makes it likely that the differences between these two types of yeast are in the accessibility of these acids to the enzymes of the cycle.

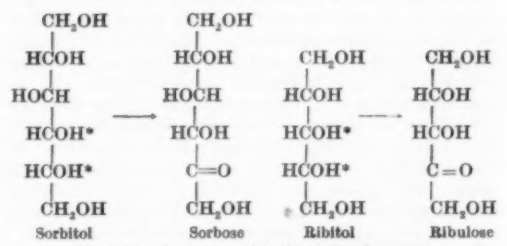
Recent work on *Brettanomyces* species[20] involved a study of their growth on polyols. The results of this work suggest the presence in these yeasts of a polyol dehydrogenase of the type described by Blakley[21,22], capable of oxidizing sorbitol and ribitol, but unable to attack mannitol, erythritol or galactitol. However, recent taxonomic literature[6,9,10,23,24] suggests that Bertrand's D-mannitol dehydrogenase[25,26] is more common among yeasts than the Blakley enzyme. Bertrand's enzyme oxidizes sorbitol, ribitol, mannitol and erythritol (Fig. 1 and Table 1). If the Bertrand enzyme is widespread, the frequent inability of these yeasts to use erythritol could be explained by postulating that it does not penetrate the plasma-membrane. Such suppositions must be checked by work with cell-free extracts, which may show the situation to be vastly more complicated than has been suggested. Meanwhile, it is mistaken to consider sorbitol utilization as a single test when yeasts may be found to possess at least three different enzymes which occur in other organisms and are capable of converting sorbitol to fructose or to sorbose[22,25,27].

The need for understanding the tests used for classifying yeasts has been emphasized from time to time by taxonomists. For example, Wickerham[28] held that the growth tests on various nitrogen sources[2] were spurious because the yeasts could grow on all these sources when given an adequate supply of vitamins; and Kudriavzev[6] considered it important to know whether the enzymes involved in fermentation



Transformations achieved by the Blakley enzyme: L-iditol dehydrogenase

(This enzyme also converts L-iditol to L-sorbose (ref. 22).)



Transformations achieved by the Bertrand enzyme: D-mannitol dehydrogenase

(This enzyme also converts mannitol to fructose, erythritol to erythrulose, D-arabitol to D-xylulose (ref. 25).)

Fig. 1. Specificity of two polyol dehydrogenases. (Asterisks indicate arrangement of hydroxyl groups for which the enzyme shows stereospecificity)

tests are adaptive. But very little has been done so far to apply methods of metabolic biochemistry to the study of different kinds of yeast, although the work that has been started along these lines, and has been briefly described above, suggests that it will prove rewarding. Not only should it make it easier to classify yeasts by making the experimental work more precise, it should also help to produce a stable classification if this is devised in such a way that each test is designed to reveal the presence or absence of a single enzyme[13,14,17]. It would also make yeast taxonomy more useful to biochemists and microbiologists in research and industry who want to know the chemical potentialities of each named yeast.

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A ROLE FOR THIOL AND DISULPHIDE GROUPS IN DETERMINING THE RHEOLOGICAL PROPERTIES OF DOUGH MADE FROM WHEATEN FLOUR

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IN 1940 it was recognized by Sullivan, Howe, Schmalz and Astleford[1] that thiol groups and disulphide bonds were involved in determining the properties of dough. Due to lack of adequate experimental methods for determining these groupings, the precise connexion remained unknown. Recently, however, there has been a renewed experimental interest in the role of sulphur from the point of view of disulphide exchange reactions[2–4].

We report here some definitive experiments which allow the formulation of a hypothesis that relates strength and elasticity of dough to thiol groups, intermolecular disulphide bonds, and the rate at which they interchange. At the same time, evidence is presented which explains the action of certain improvers in terms of disulphide interchange. The experiments were carried out with one flour only—a commercial, unbleached flour milled from Victorian *F.A.Q.* wheat.

Thiol and Disulphide Content of Flour and Extracts of Flour

Thiol and disulphide groups were measured in the whole flour and extracts of flour by amperometric titration of excess methylmercuric iodide[5]. This reagent was added with the dispersing medium in order to limit oxidation of thiol groups during the preparation of the dispersions. The results are given in Table 1. For convenience the results are expressed on the basis of 300 gm. of flour, as this was the weight used in the rheological experiments. The flour contained 12·5 per cent moisture and 1·41 per cent nitrogen. It can be seen that the flour and both fractions derived from it contain thiol and disulphide groups. Further, only a proportion of the total thiol groups found in the presence of urea are readily available for reaction in aqueous suspension with methylmercuric iodide. It is likely that these thiol groups measured in aqueous suspension more nearly represent those available for disulphide bond exchange reactions. Both saline-soluble and gluten proteins can therefore play acceptor and donor parts in such reactions. It is apparent, too, that the saline-soluble fraction on a nitrogen basis is richer in thiol and disulphide groups than the gluten fraction. As the gluten fraction is less soluble, mobility of protein in

Table 1. Thiol and Disulphide Content of Flour and Flour Extracts

Thiol and disulphide contents calculated on basis of 300 gm. air-dried flour

Material	Medium in which —SH and —S—S— groups measured	μmole —SH	μmole —S—S	Percentage of total nitrogen
Whole flour	Water suspension	184		100
Whole flour	Urea (8 *M*) dispersion	450	2,220	
Saline extract	Urea (8 *M*) dispersion	174	840	
Saline extract	No urea	132		23·7
Residue from saline extract	Water suspension	52		76·3
Residue from saline extract	Urea (8 *M*) dispersion	280	1,560	

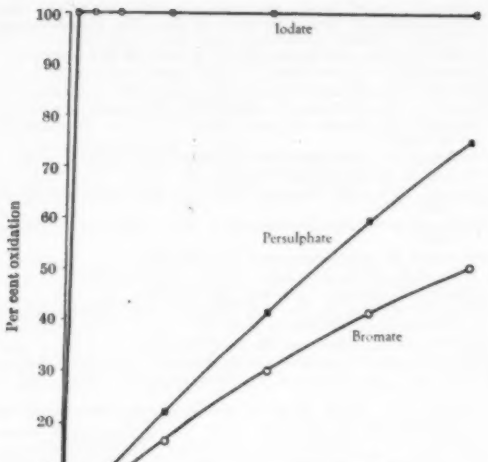

Fig. 1. Oxidation of glutathione by iodate, persulphate, bromate and chlorate plotted against time at *p*H 6·0 and 28°. Concentration of glutathione, $6{\cdot}67 \times 10^{-4}$ *M*; oxidizing agents, 2×10^{-3} *M*

dough would be due more to the saline-soluble proteins.

Reaction of Thiol Groups with Iodate, Bromate, Persulphate, Chlorate and N-Ethylmaleimide

Oxidation of glutathione, as a model compound, by iodate, bromate, persulphate and chlorate has been followed spectrophotometrically by the method of Boyer[6]. Fig. 1 shows that of the oxidizing agents used, iodate acts very rapidly, bromate and persulphate slowly, and chlorate not at all. Similar results have been obtained with cysteine. Chromatography with phenol/water showed that in the case of cysteine the main product is the disulphide cystine, with small amounts of cysteinesulphinic and cysteinesulphonic acids. Table 2 shows that gluten reduced with sodium borohydride also has its thiol groups oxidized at similar rates by iodate, bromate and persulphate. A full account of the oxidation of thiol groups by iodate, bromate and persulphate is in preparation and will be presented elsewhere. It is of interest that the rates of oxidation of thiol groups by the oxidizing agents used are closely paralleled by their well-known rates of action as improvers in the bread industry[1,7,8].

Table 3 shows that the addition of iodate and N-ethylmaleimide to suspensions of flour brings about a considerable decrease in the readily available thiol groups. In a qualitative way, these decreases support the inferences drawn from the effect of these reagents in the rheological experiments described later. Quantitatively, however, it is likely that, when mechanically mixed, the decrease in total thiol groups of the dough would be greater than that obtained with suspensions of flour.

Table 2. Oxidation of Reduced Gluten by Bromate, Iodate and Persulphate

Reduced gluten (10 mgm./10 ml.) finely suspended in citrate buffer 0·5 *M* at *p*H 6·0. Oxidizing agent (1·2 m*M*) added in 1 ml. After appropriate interval, methylmercuric iodide added and excess determined amperometrically. Results calculated on basis of moles/10^5 gm.

Time	Moles of —SH groups expressed per 10^5 gm. by Iodate	Bromate	Persulphate
0	11·5	10·5	11·0
1 min.	2	—	—
3 min.	1	—	—
5 min.	0	—	—
30 min.	0	—	—
3 hr.	—	7·5	10·0
6 hr.	—	6·0	7·5
9 hr.	—	5·0	7·0

Table 3. Reaction of Thiol Groups of Flour with Iodate and N-Ethylmaleimide

Flour (1 gm.) suspended in 0·624 *M* sodium chloride (10 ml.) and iodate and *N*-ethylmaleimide added in amounts indicated after reaction time of 5 min.; a further 9 ml. of 0·624 *M* sodium chloride was then added. Residual thiol groups were then estimated by amperometric titration with methylmercuric iodide. Results calculated to 300 gm. flour which contained 180 μmoles of readily available thiol groups

Iodate		N-ethylmaleimide	
Iodate added (μmole)	Thiol in flour suspension (μmole)	N-ethylmaleimide added (μmole)	Thiol in flour suspension (μmole)
0	180	0	180
		45	132
15	150	90	96
30	138	180	96
75	126	360	90
150	120	720	84
300	111		
1,500	96		

Action of Iodate, N-Ethylmaleimide and Cysteine on the Rheological Properties of Dough

The rheological properties of the dough were studied using the commercial instruments—the Brabender farinograph and extensograph. These instruments respectively measure resistance to mixing against duration of mixing, and resistance to extension against distance extended.

Fig. 2 shows that the presence of iodate and N-ethylmaleimide alter the mixing properties of the dough initially in such way as to increase the resistance to mixing and later to lower it. Similar responses on farinograms have been shown by Mecham[2]. The effects of iodate and N-ethylmaleimide are even more marked when measured with the extensograph (Fig. 3). (See also Goldstein[3].)

From the known chemistry of iodate (Fig. 1) and N-ethylmaleimide (Table 3 and Friedmann *et al.*[9]), the effects obtained can be related to the disappearance of thiol groups. In the case of iodate there is the further possibility described earlier, of formation of new intermolecular disulphide bonds which would

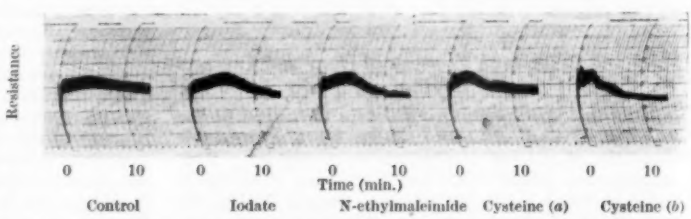

Fig. 2. Farinograms of 300 gm. flour, mixed with 163 ml. water containing 6 gm. sodium chloride and the reagents indicated. Flour contained 450 μmoles thiol and 2,220 μmoles disulphide; iodate, 45 μmoles; N-ethylmaleimide, 150 μmoles; cysteine (*a*) 75 and (*b*) 300 μmoles

be expected to strengthen dough. In the case of N-ethylmaleimide, there seems to be only one possible explanation of the effects observed, namely, the disappearance of thiol groups prevents disulphide interchange by removal of one of the necessary components. Expressed in another way, a stable intermolecular disulphide network that does not yield to stress is formed—the result being a tough, non-extensible or stabilized dough.

Figs. 2 and 3 show also that mixing of dough stabilized in this way destroys certain of the bonds responsible for resistance and at the same time increases the extensibility. It follows from these observations that, even in untreated doughs, the rate at which the shearing forces are applied during mixing will affect the rheological properties of the product, depending on the rate at which the exchange reactions can keep pace with the rate at which the stress is applied.

The effect of concentration of iodate and N-ethylmaleimide when mixed with the dough for 1·5 min. is shown in Fig. 4. It is not possible to say whether these two reagents have reacted completely with the thiol groups in the dough under the mixing conditions used but, assuming complete reaction, a rough quantitative estimate (a maximum) of the number of thiol groups involved in the observed effects can be put at 33 per cent of the total thiol groups. With N-ethylmaleimide, the figures, with this proviso, are more certain as this reagent is monofunctional. In the case of iodate, however, there can be no certainty, as the oxidation may proceed within the two extremes:

$$IO_3^- + 6RSH \rightarrow I^- + 3R\text{-}S\text{-}S\text{-}R + 3H_2O \quad (1)$$

$$IO_3^- + RSH \rightarrow I^- + R\text{-}SO_3H \quad (2)$$

However, leaving aside the question of stoichiometry in the reaction between iodate and the thiol groups of flour, its effect is very similar to that of N-ethylmaleimide at similar concentrations.

The effect of adding varying concentrations of cysteine to the dough can be seen in Fig. 2 and Fig. 5. With increasing concentration, strength decreases; and at the higher concentrations the extensibility is so great that the instruments cannot measure the resistance. The figures presented express cysteine added as percentage of total disulphide bonds broken, but reduction in the strength of the dough would be due not only to destruction of intermolecular disulphide bonds but also to an increased rate of their

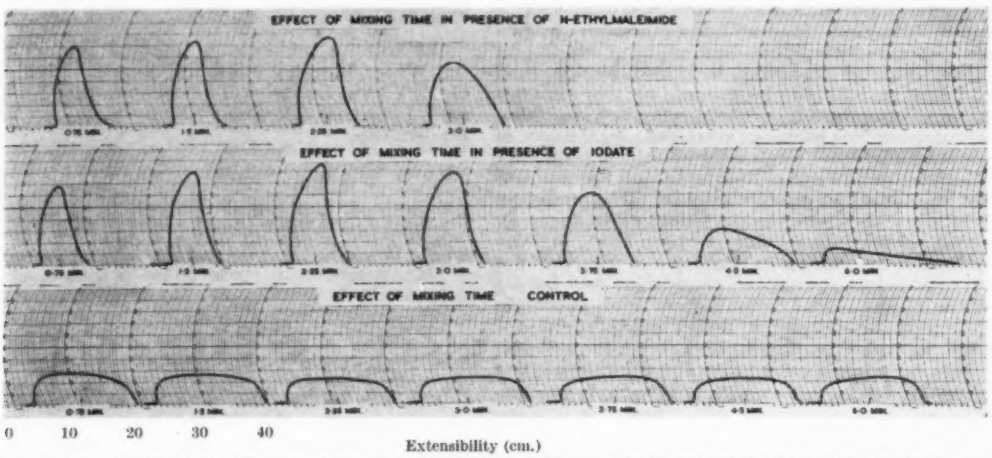

Fig. 3. Extensograms showing effect of mixing time on doughs treated with amounts of iodate and N-ethylmaleimide in molar proportions to the thiol groups present in the dough (300 gm. flour, 163 ml. water). After 3 min. mixing with N-ethylmaleimide, the dough was too sticky to handle and further times could not be investigated

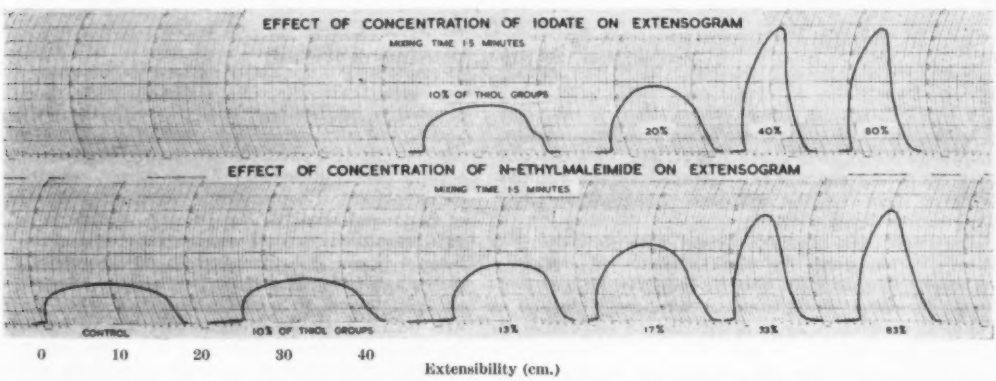

Fig. 4. Water (163 ml.) containing 6 gm. sodium chloride and increasing amounts of iodate and N-ethylmaleimide added to 300 gm. flour which contained 450 μmoles thiol groups. The percentages indicated refer to equivalents of reagent in relation to thiol groups present. In the case of iodate, calculations were made on basis of: $6\,RSH + IO_3^- \rightarrow R\text{-}S\text{-}S\text{-}R + 3\,H_2O + I^-$

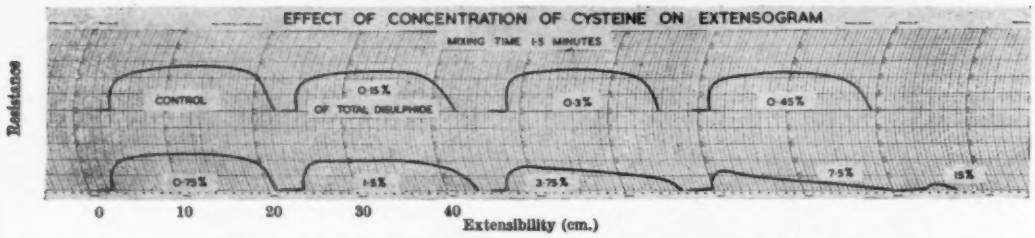

Fig. 5. Extensograms showing the effect of increasing amounts of cysteine. For conditions and disulphide content of flour, see Fig. 2. Percentages given represent μmoles cysteine in relation to μmoles disulphide present in the flour

interchange. However, it can be stated that only small percentage changes in these bring about a marked loss of strength and increased extensibility.

Conclusions

At any given protein content of flour, it appears likely that the rheological properties of dough are directly related to the number of intermolecular disulphide bonds and the rate at which they can interchange with thiol groups. A useful approach to the problem of quality differences in wheats would seem to be, that their related doughs differ with respect to either or both of these properties. In this respect it is likely that both water-soluble proteins and gluten fractions of the flour are involved.

The action of improvers, both thiol-blocking and oxidizing agents, can be related to this concept, namely, strengthening of the dough through inhibition of disulphide exchange reactions. In the case of oxidizing improvers, there is the additional possibility of increase in strength of dough through formation of new intermolecular disulphide bonds. The preference in industry for bromate over iodate as an improver can be related to the slower oxidation of thiol groups by the former, leading to the slow development of a stable structure during the preparation and baking of the dough. The action of reducing agents in destroying the structure of dough can be interpreted both as lowering the number of intermolecular disulphide bonds and/or increasing the rate of their exchange.

In the discussion so far, emphasis has been placed on the quantitative importance of intermolecular disulphide bonds and their rate of exchange in determining the strength of the dough. However, components other than proteins and other types of bonds play a part in determining the total rheological properties. In this connexion it is suggested that hydrogen bonding between the amide groups of the large number of glutamine residues of gliadin[10] play a major part in determining the solubility properties. Intermolecular disulphide bonds could then be regarded as stabilizing the more fluid hydrogen-bonded system.

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EXPLORATORY BEHAVIOUR IN THE RAT*

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RECENT studies have shown that a rat, confronted with novel, environmental stimulation, manifests much investigatory activity. This exploratory behaviour reduces the 'newness' of the stimulation, so that as the situation becomes familiar exploration diminishes.

Berlyne[1,2] has been concerned with developing a theory to account for the satiation of curiosity responses in rats. In this he employs Hull's[3] two-factor theory of inhibition. A temporary decline in exploratory behaviour is attributed to accumulation of reactive inhibition, while a more slowly developing, permanent decline is interpreted in terms of the acquisition of a conditioned resting-response, that is, conditioned inhibition. These terms require some explanation. Reactive inhibition may be thought of as a negative drive state akin to avoidance of pain. It is an inhibition produced by response and resembles fatigue; and it is believed to be dissipated during periods of rest. If rest periods are too short to allow for dissipation of reactive inhibition when responses are being elicited continuously, there develops an increasingly strong tendency for the cessation of response. When resting occurs, a quantity of reactive inhibition is dissipated. Dissipation of reactive inhibition during rest constitutes reinforcement, so

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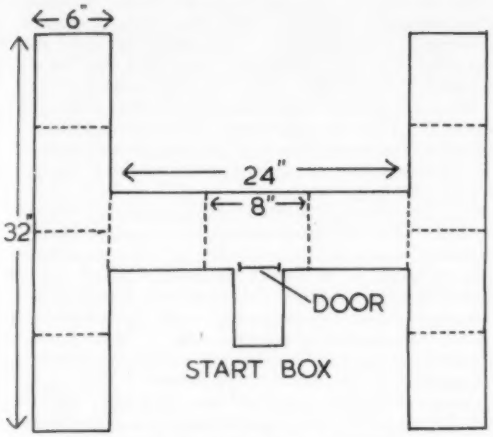

Fig. 1. A plan of the maze used. Exploratory activity was measured by counting the number of 8-in. units an animal entered in each minute. These are shown by the broken lines on the figure

that the response of resting becomes conditioned to whatever stimuli are present in the situation. This acquired tendency to rest is conditioned inhibition.

Thus Berlyne showed[2]: (i) rats enter an alcove in an exploratory box more frequently if it contains a novel object (for example, a wooden cube) than if it is empty; this supports the view that a novel stimulus evokes the curiosity drive; (ii) the amount of curiosity declines rapidly with continuous exposure to a novel object; this decline is interpreted in terms of the accumulation of reactive inhibition, primarily; (iii) there is a relatively permanent decrement in curiosity after initial exposure; rats enter the alcove of an exploratory box to investigate a novel object less frequently as daily trials proceed and this is taken to support Berlyne's application of conditioned inhibition to explain the adaptation of curiosity responses.

While Berlyne found evidence to support this theory, Montgomery[5] did not. Working at Yale University, Montgomery studied exploratory behaviour in simple maze environments. Typically, rats are placed in an *H*-maze, the alleys of which are marked out in 12-in. units. The number of units an animal enters in each minute of a 10-min. trial constitutes a measure of exploratory activity. Rats tend to enter many units initially, whereas few are entered towards the end of a trial. Montgomery also found that if a 10-min. trial is given each day, there is full 'recovery' of maze exploration. Therefore, he concluded that conditioned inhibition was not applicable because he could find no evidence for a permanent decrement in exploratory activity.

Berlyne stated, in reply: "We can only hazard the suggestion that maze runways present a large assortment of novel stimuli, so that a ten-minute exploration period may not allow enough time to satiate the curiosity aroused by most of them to the point at which a permanent decrement occurs" (ref. 2, p. 245). However, he did not test this supposition. Thus, a controversy continues to exist, and an experiment was designed to clarify it.

The apparatus consisted of an enclosed *H*-maze, the main dimensions of which are shown in Fig. 1. The walls of the maze were 6 in. high, and the maze was covered with plate glass. The centre piece of the *H* was painted white and the two arms grey. Each alley was marked off in 8-in. segments. The maze was placed in an arena 5 ft. square, and 4 ft. high. This enclosure was constructed with metal strip, and covered with butter-muslin. Thus, the maze was enclosed in a relatively homogeneous environment. Further, it was illuminated by three red 15-W. lamps suspended above the maze. These afforded a low but even source of illumination. During the maze trials, the room was in darkness, so that the butter-muslin enclosure provided an efficient one-way screen, that is, the observer could watch an animal with little danger of distracting it by his own movements. An animal was placed in the starting box for 1 min. before the door was raised, thus allowing a brief period of adaptation before any trial commenced.

The subjects were 15 male albino rats of 110 days of age. Of these 15 animals, 6 were 'non-reactive', and 9 were 'reactive'. These animals were the offspring of breeding nuclei of the 10th generation of Maudsley Reactive and Non-reactive strains, respectively, which originally formed a part of a selective breeding study of emotionality which is being conducted at the Institute of Psychiatry (Maudsley Hospital), Animal Psychology Laboratory, London[3]. (I am indebted to Dr. P. L. Broadhurst for allowing us to purchase this stock for use in Sheffield.) Unfortunately, it was not possible to submit these animals to the open-field test at the time of this experiment, although this technique[3] was used in later work.

After each animal had been habituated to handling, they were assigned randomly to one of three groups, designated *A*(20), *B*(40) and *C*(60), respectively. There were five rats per group. On day 1, each animal received a 20-min. trial in the maze. On day 2, group *A*(20) received a 20-min. trial, group *B*(40) a 40-min. trial, and group *C*(60), a 60-min. trial. This procedure was repeated on days 3 and 4.

After the appropriate trial on day 4, the animals were returned as usual to their home cages, where they remained, untouched, for 9 days. On the tenth day, each animal was given one 20-min. trial in the maze. Throughout the experiment, all animals were supplied with food and water *ad libitum*, except when in the maze.

The number of maze units entered in each minute of a trial constituted the measure of exploratory activity.

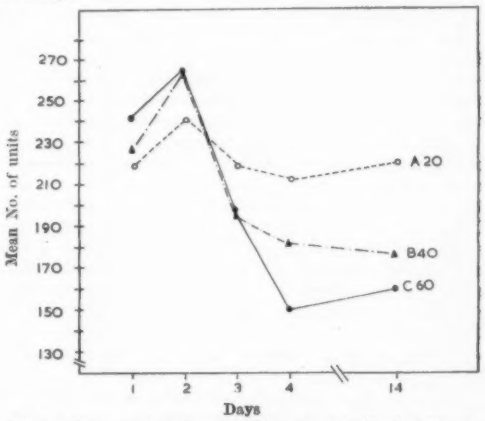

Fig. 2. Mean number of maze units entered in the first 20 min. by each of the groups during their daily trials

Four main results emerged from this work. These may be seen from Fig. 2. In the first place, there were no significant differences between the groups in amount of exploration during the 20-min. trial of day 1. Nor were any differences found between the reactive and non-reactive rats on day 1. (The results were analysed by non-parametric techniques.)

Secondly, a comparison of the mean amount of exploration on day 1 with that on day 2 revealed a significant increase for the 15 rats taken as a whole. Further analysis showed that the reactive rats were mainly responsible for this, in that their day 1 to day 2 increase was significant ($P = 0{\cdot}05$), whereas that of the non-reactive animals was not.

Thirdly, differences between the groups failed to reach significance on day 3. However, on day 4, the difference in exploration between groups $A(20)$ and $C(60)$ during the *first* 20 min. was highly significant ($P = 0{\cdot}004$). The difference between groups $A(20)$ and $B(40)$ did not reach an acceptable level.

Lastly, the differences in mean exploration scores after a period of 9 days absence from the maze reveal a decrement for those rats given extended periods of exploration during the first phase of the experiment. The difference between $A(20)$ and $B(40)$ was significant at $P = 0{\cdot}05$ (two-tailed test); the difference between group $A(20)$ and group $C(60)$ was significant at a more acceptable level ($P = 0{\cdot}01$). However, the mean difference between group $B(40)$ and group $C(60)$ was not significant.

The first result, namely, the day 1 to day 2 increase in exploration, has not been reported, previously, by other investigators. However, it has been suggested that novel stimuli may elicit fear as well as curiosity[6], and this effect may be due, therefore, to the extinction of fear responses elicited during the first trial. This view gains support in that emotionally 'reactive' rats manifest this increase more markedly than 'non-reactive' animals. Further research is needed to test this hypothesis.

With regard to a controversy concerning the permanency of a decline in exploratory tendencies after repeated exposure, the results of this experiment lend support to Berlyne's position. They suggest that Montgomery failed to allow rats sufficient time to explore a novel environment to the point at which a more permanent decrement occurs. More research is needed to confirm the adequacy, as opposed to the usefulness, of Berlyne's hypothesis. However, a neurophysiological basis for the inhibitory concepts of this theory may be found in experiments[7] concerning habituation of the arousal response in cats.

I am indebted to Dr. Peter McKellar for supervision and help in conducting a series of experiments of which the present experiment is a part.

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THE AFFINITIES OF THE NEW OLDUVAI AUSTRALOPITHECINE

DR. L. S. B. LEAKEY recently reported in *Nature*[1] the discovery of an essentially complete hominid skull without mandible from site *FLK* at Olduvai Gorge. He regards the specimen as an australopithecine that differs more from either of the two known genera, *Australopithecus* and *Paranthropus*, than these two differ from each other. He therefore erected the genus *Zinjanthropus* to accommodate the new specimen.

The description consists largely of a list of twenty 'major' differences between the new specimen and the two previously known genera. Some of these points cannot be dealt with as they are briefly stated in terms which are not useful by themselves for comparison. Others, for example, continuous nuchal crest, enlargement of the mastoid area, prominent temporal lines, large areas for masseter attachment, etc., do not each represent a separate difference; all are reflexions of the fact that this specimen is a little larger and more muscular than the known South African specimens of *Paranthropus*. In at least one case (nuchal crest) comparison with the latter specimens is not possible since there is no known male specimen with the relevant area preserved. The remainder are not real differences and will be dealt with briefly:

(1) The inion is lower relative to the Frankfort plane: In both *Australopithecus* and *Paranthropus* the base of the external occipital protuberance is almost exactly in the Frankfort plane, as seems to be the case with the Olduvai specimen.

(2) The posterior wall of the occipital bone rises more steeply to form, with the parietals, a very high-vaulted posterior region of the skull: This is also the case in *Paranthropus*, less so in *Australopithecus*. *Paranthropus* has an almost spheroidal brain-case which is relatively low and narrow anteriorly but steep-sided and higher posteriorly. *Australopithecus* has a brain-case more nearly like that of a dolichocephalic modern hominine. The Olduvai specimen has the *Paranthropus* type of brain-case.

(3) The form of the tympanic plate is different: Dr. Leakey demonstrated this point to me on the specimen to make clear his meaning. This feature is variable in *Paranthropus* and includes an instance of close resemblance to the Olduvai specimen. The observed range of variation is illustrated in Fig. 1. Being thus variable, it is in any event a feature of low phyletic valence.

(4) The very unusual position of the nasion—almost coinciding with glabella: This is true of *Paranthropus* and in at least some cases of *Australopithecus* also. In *Paranthropus*, as in the Olduvai specimen, the nasals are relatively very wide near the nasion.

(5) The very great absolute and also relative width of the inter-orbital area. The proportionate width of the inter-orbital area to that between the external orbital angles is 26·6 in the Olduvai specimen; 26·2 (*SK* 846), 25·3 (*SK* 48) in two specimens of *Paranthropus*. A single specimen of *Australopithecus* gave a value of 24·1, while a random sample of eight

Fig. 1. Variation of the tympanic bone at the lateral end of the external auditory meatus in *Paranthropus* from Swartkrans (*SK* 48, *SK* 52 and *SK* 848). The Olduvai specimen resembles in this feature the condition illustrated in the middle diagram

modern human skulls gave a range of 23·4–30·5. No taxonomic significance can therefore be attached to this point on the present evidence.

(6) The very deep palate which is even more markedly like that of *Homo* than *Australopithecus*, and is quite unlike the form seen in *Paranthropus*: In *Homo*, the degree of vaulting of the hard palate is variable, but the difference in depth at the incisive fossa and the back of the palate is normally relatively slight. This is true also of *Australopithecus*. The palate of *Paranthropus* differs in that it slopes more markedly; that is, there is always an appreciable difference between the anterior and posterior depths —in some cases there is no depth at all anteriorly, in others the anterior depth is appreciable. The Olduvai specimen shares this characteristic of relatively much greater posterior compared to anterior depth, reflecting the *Paranthropus* condition, not that of *Homo* and *Australopithecus*.

(7) The shape and arrangement of the zygomatic process of the maxilla: The Olduvai specimen has a relatively poorly developed zygomatic process, the lower border of which passes almost horizontally from the zygo-maxillary suture to the main body of the maxilla. In some specimens of *Paranthropus* the process passes from the zygo-maxillary suture downward and medial-ward at a fairly sharp angle like an inverted flying buttress. However, *SK* 52, of the same dental age as the Olduvai specimen, has a trace only of the buttress and *SK* 846 (mature adult) has no trace of it, as in the Olduvai specimen.

(8) The relatively greater reduction of the canines in comparison with the molar-premolar series than is seen even in *Paranthropus*: As the marked change of proportion between anterior and cheek teeth occurs in *Paranthropus* and the Olduvai specimen between canine and P^3, the degree of reduction can be measured by the ratio between the modules of these two teeth. The ratio for the Olduvai specimen is 64·9 while that for three specimens of *Paranthropus* ranges from 61·8 to 78·8.

(9) In the species diagnosis Leakey refers to the presence of a sagittal crest "at least posteriorly". The reason for this statement is not clear, since the crest occupies a position identical to that in *Paranthropus*—on roughly the middle third of the distance between glabella and inion. In neither form is the sagittal crest known to reach as far back as the planum occipitale or even the posterior part of the sagittal suture.

It seems to me that the most fruitful approach to an understanding of the australopithecine skull, within the framework of hominid structure, is in terms of diet and the nature of the dentition. *Australopithecus*, as an omnivore eating at least a moderate amount of flesh, has a dental apparatus very similar to that of the older hominines. The relative sizes of the teeth along the tooth row are closely similar, as is the arrangement of the dental arcades. The anterior teeth, especially the canines, are well developed, but the post-canine ones only moderately so. The skulls are also similarly constructed except for the relatively small cranium, compared to the face, of *Australopithecus*.

In *Paranthropus* the situation is very different. Here the anterior teeth, set in an almost straight line across the front of the palate, are appreciably reduced in size compared to those of *Australopithecus*, while the post-canine teeth are appreciably larger. This difference in arrangement and proportion is very striking and is characterized by the very small canine tooth set firmly against a massive premolar. All this must clearly have functional meaning. The massive crushing and grinding teeth, the relatively unimportant anterior teeth and frequent damage to the enamel which could only have been caused by small, very hard particles (presumably grit), and the large size of the animal suggest a predominantly vegetarian diet. Concentration of heavy dental function in the post-canine region has strongly modified the skull architecture. The massive cheek teeth, especially the molars, have strongly developed root systems and hence are set in heavy bone, and the back of the palate is relatively deep. Owing to the heavy chewing forces, the palate is thick, the jaws are massive, especially where supporting the cheek teeth, the zygomatic arches are strongly built, the circumorbital bone is strong in the stressed areas, the strongly stressed pillars on either side of the pyriform aperture are thick and the medial and lateral pterygoid plates, especially the latter, are large and strong. However, the large dental battery requires heavy musculature to operate it—hence further changes from the *Australopithecus* and hominine pattern. The areas of origin and insertion of these muscles are sturdy; hence the large surface area of the mandibular ramus, the massive zygomatic arch—which also is widely spaced from the brain-case to allow for the very large temporal muscle—large medial and lateral pterygoid plates, clearly defined temporal lines, sagittal crest and apparent prominence of the supraorbital tori. The large muscles associated with the large and chunky animal result in well-defined muscular ridges on the occiput and the prominence of the mastoid area—assisted by the large temporal muscles which necessitate appreciable lateral extension of the zygomatic arch. It is probable also that the large temporal muscles have influenced the shape of the brain-case anteriorly to help produce the low and narrow shape characteristic of *Paranthropus*. As is usual in relatively massive skulls where large surface area is necessary, some reduction of weight has occurred by increased pneumatism. The mastoid region (not the mastoid process alone) is strongly cellular and the air spaces in the skull base, the maxillæ and the frontal bone are all very large.

The curious and characteristic features of the *Paranthropus* skull, which parallel some of those of the gorilla skull and mark it off so clearly from that of *Australopithecus*, are all functionally related and determined largely by the specialized diet of this creature as compared to all other known hominids. These functional and structural differences indicate clear adaptational differences between the two forms and hence also differences of evolutionary direction. In modern systematics, adaptational differences of this order and nature are normally accorded generic rank.

The features of the Olduvai specimen fit the *Paranthropus* pattern as here outlined very accurately—

the differences being almost entirely of the sort shown to be variable within a single population by the sample of nearly 200 specimens of *Paranthropus* now in the collections of the Transvaal Museum. The chief feature of the Olduvai form which does not fall within the observed range of variation of this collection is size. The best size comparison is with the only male specimen with good teeth which has P^3–M^1 preserved in sequence and is of the same dental age as the Olduvai specimen. The latter is only 8·4 per cent larger. The average percentage difference for five skull and dental series dimensions compared to those of a fully adult female skull is 17·4 per cent. As Schultz has shown in a number of papers, intra-specific variation in measurable primate anatomical characters can often greatly exceed the above values.

The validity of separate specific status is not clear on the basis of the single specimen, and it is perhaps wisest to leave it as distinct. In the light of the above analysis, however, separate generic status seems unwarranted and biologically unmeaningful. I therefore propose that the name of the Olduvai form be *Paranthropus boisei* (Leakey).

J. T. Robinson

Transvaal Museum,
Pretoria.

[1] *Nature*, **184**, 491 (1959).

The exact taxonomic label that should be applied to the skull that I have named *Zinjanthropus*, from Olduvai, and which I described in *Nature* of August 15, 1959, seems to me relatively unimportant at the moment. Inevitably, different scientific workers have different ideas of what characters justify specific, generic, and even superfamilial rank. After all, this is purely a question of artificial labels.

Dr. Robinson and I agree that *Zinjanthropus boisei* is closely related to the Australopithecinae; we agree that it has certain resemblances to *Paranthropus*, and we disagree mainly in that he believes the differences to be insufficient to justify separate generic rank, while I think they do.

It is hard enough to reach agreement among zoologists on the taxonomic status of living primates, under conditions in which we possess the skull, skeleton, skin and viscera for study, and it will always be much more difficult to do so when we have only fossils to guide us. I can only say that the very considerable additional work that I have done on the *Zinjanthropus* skull since my preliminary report in *Nature* has greatly strengthened my view that it is entirely different from *Australopithecus* and *Paranthropus*, differing from both these genera more than they do from each other.

I do not feel that any useful purpose would be served by entering into a long discussion with Dr. Robinson in *Nature* at present, since the more detailed study of the Olduvai skull which is now in hand will not, I hope, be too long delayed. However, Dr. Robinson makes certain statements which may mislead those who read them, unless I comment on them. I will therefore do so as briefly as possible.

First of all, whereas in *Paranthropus* and *Australopithecus* (as Dr. Robinson says) the external occipital protuberance lies more or less on the Frankfort plane, in *Zinjanthropus* it lies below it.

Robinson's description of the brain case of *Paranthropus* as "almost spheroidal", but also "relatively low and narrow anteriorly but steep-sided and higher posteriorly", does not seem to make sense, for the two statements seem to cancel each other out. In any event, such a combined description does not fit the brain case of *Zinjanthropus*.

Robinson illustrates the range of the tympanic plate (see in profile), in *Paranthropus*. None of these three illustrations closely resembles the tympanic plate of *Zinjanthropus*, although the one to the left appears to be rather closer than the middle one.

Without knowing the points at which Robinson measures inter-orbital width and external orbital width, I cannot comment upon his comparisons of his *Paranthropus* figures with mine for *Zinjanthropus*.

As to the morphology of the palate, I do not know upon what evidence Robinson is basing his statement, since I have published no measurements of the palatal depth in *Zinjanthropus*. I must repeat, however, quite categorically, that the morphology of the *Zinjanthropus* palate in no way resembles that of *Paranthropus*.

I cannot accept Robinson's statement that the zygomatic process of the maxilla in *Zinjanthropus* is "relatively poorly developed"; I would say rather, as I have said before, that it is developed in an entirely different morphological manner from *Paranthropus*.

As regards the position of the sagittal crest, in *Zinjanthropus* it ceases to be a crest and divides into two temporal lines well behind the line drawn vertically through the ear when the skull is on the Frankfort plane. In *Paranthropus* (in all the published photographs), the sagittal crest extends a long way forward of such a vertical line through the ear when the skull is on the Frankfort plane, and it is therefore wrong to say, as Robinson does, that "the crest occupies a position identical to that in *Paranthropus*".

Finally, I do not understand the significance of a comparison of "the ratio between the modules of these two teeth", that is, the canine and P^3. Robinson has defined a module as the sum of the length and breadth of a tooth divided by two, and I am at a complete loss to understand how the ratios of modules can have any significance. It must be obvious that one can have on one hand a canine tooth 16 mm. long and 6 mm. wide (module equals 11), and a premolar 9 mm. long and 7 mm. wide (module equals 8), while in another specimen one could have a canine which measured 11 mm. × 11 mm., and a premolar which was only 5 mm. long and 11 mm. wide, yet the ratio of the modules in the two sets of teeth would be identical, but completely without significance.

In any event, the ratio between the canine and the premolar alone cannot have any bearing upon the relation of the canine size to the total molar–premolar series, unless the premolar bears a constant relation to the total post canine series.

I therefore repeat my statement that in *Zinjanthropus* there is a relatively greater reduction of the canines in comparison with the total molar–premolar series than is seen in *Paranthropus*, and maintain that Robinson has in no way disproved this statement.

I agree with Robinson that we need to study the *Australopithecus* skull structure and dentition in terms of diet and mode of life, and I shall certainly do so as far as *Zinjanthropus* is concerned in my fuller report.

L. S. B. Leakey

Coryndon Museum,
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LETTERS TO THE EDITORS

PHYSICS

Comparison of the Charges of the Electron, Proton and Neutron

We have noted the communication from Bondi and Lyttleton[1] criticizing our experiment[2] and we would like to clarify the alleged obscurities.

Bondi and Lyttleton suggest that a supply of electric charges may be detached from the walls of the nozzle, and that if the gas is not electrically neutral it will attract these charges into the gas until it is neutralized. For this mechanism to work two conditions must be satisfied. First, it is necessary to find a process for the production of free charges, and secondly, a process which arranges that the charge carried away by the gas is controlled by the space-charge field, so that charge is carried away just until the space charge has been neutralized. We examine these two conditions in turn.

(1) The observed probable upper limit of the space-charge of the emerging gas was 3×10^{-14} coulomb on 81 litres, or $3{\cdot}6 \times 10^{-13}$ coulomb/m.^{3}. Consider whether a gas with five times this space-charge density (that is, $1{\cdot}8 \times 10^{-12}$ coulomb/m.^{3}) could produce neutralizing charges. Such a space-charge would produce a field intensity, E_s, of 5×10^{-4} V./m. at the surface of the tube, which is too small by a factor of 10^9 to produce field emission of electrons and too small by a larger factor for the production of ions. Surface ionization, the capture of an electron from an impingeing atom, resulting in a surface charge can occur when it is energetically possible. In the present case, the ionization potentials of argon and nitrogen are 15·6 and 14·5 volts respectively, whereas the work function of brass is only about one-third of these values. Proportional counters have been operated successfully with a continuous flow of gas and with fields at the walls many orders of magnitude greater than E_s, indicating that the flow causes no production of ions. Presumably dust or water drops would have to be present in the gas in order to liberate charges from the walls, which is not the case in our experiment.

(2) We now consider the motion of charges supposed to be released at the wall surface. The field due to the space-charge is far from "amply sufficient to drag along charges", for in addition to the field E_s acting on the charge there is a field due to the image charge in the conductor attracting the free charge back, and this exceeds E_s within 1·0 mm. of the wall (or more than a third of the cross-sectional area). Also there are contact potential differences of the order of 10 mV. between different points of the brass surface, giving field intensities of ~ 1 V./m. Even in the latter field, ions or electrons would move much faster by thermal diffusion than their average motion along the lines of force. Hence the motion of any ions or electrons liberated from the surface by friction would be determined mainly by random diffusion (modified by turbulence), to a lesser extent by the irregular surface fields, with the space-charge fields a few thousand times weaker still. Equilibrium ion and electron densities must therefore be determined mainly by the rates of production and of diffusion loss, and in any event not by making the field component due to space-charge equal to zero. It is, in fact, precisely because the motion of the charges is governed by diffusion that objects can become charged by frictional effects. In these cases the charges are moved in opposition to fields many orders of magnitude greater than those under discussion here.

The remaining points referred to by Bondi and Lyttleton appear to arise from a misunderstanding of the experimental method. They state that it is not clear what happens to the free charges collected by the ion trap. Even if the fate of these ions were really obscure, which it is not, it is clear that the charges do not leave the box A which contains the battery. They cannot therefore influence the potential difference between boxes A and B. Bondi and Lyttleton also state that a "potential of the same order as would be expected in the absence of balancing electrons is actually applied to the very box the potential of which it is wished to measure". The potential applied was in fact considerably larger than the potential measured, but the measurements made are of changes of potential. No one has ever suggested that the potentials of thousands of volts applied to the collectors of ion chambers make the small changes due to the collection of ions inherently more difficult to detect.

Bondi and Lyttleton also have difficulty in finding the "meaning of the large ionization current in the air, the fluctuations of the measured current, and the sudden changes of potential". The ionization in the air around box A was due to natural radioactivity and cosmic rays. There is a partial separation of charges by the contact potential differences between the different metals used in the construction, resulting in a current if a suitable compensating potential is not applied. The changes of potential involved in an experimental run ($\sim 10^{-4}$ V. at the input of the feedback vibrating reed electrometer) did not change the ionization current significantly. The fluctuations in background current were at least mainly due to ions carried by air eddies (normally one sign of ion is in excess). The sudden jumps of potential occurred when the pressure was changed in the slightly flexible outlet tubes to start the gas flowing: the facts that this caused a small movement and that a small movement caused potential changes were verified. In any event the jumps were independent of the amount of gas released.

Bondi and Lyttleton refer to the "minute difference of charge concerned". In the context of the experiment, this may be misleading. The postulated charge difference is equivalent to about 100 electronic charges per c.c. This is much larger than the charge density in an ion chamber under normal conditions, and about the same as the number of ions in air at sea-level. By commonly accepted standards, the charge involved in our experiment is quite large, but the fields are very small.

In addition to the comments of Bondi and Lyttleton, it has been pointed out to us by J. Leverett

Davis that it is possible to make a plausible extrapolation of our measured points which leads to an upper limit for the charge which is nearly twice the value quoted in our communication, but still too small to remove the conflict with the hypothesis of Bondi and Lyttleton.

We do not wish to imply that our experiment is infallible, but we believe that if a loophole exists it is one that has not yet been mentioned. Nevertheless, we consider that a hypothesis as important as that suggested by Bondi and Lyttleton cannot be dismissed by one experiment, or two of a similar type, and feel that it is highly desirable that other experiments should be made which do not depend on flowing gases.

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Profile of Upper-Atmosphere Air Density at the Height 180–212 km. derived from the Orbit of *Sputnik* III

The resistance of the air to a moving object like a satellite causes a steady decrease of the semi-major axis and eccentricity of the orbit. The motion of the satellite grows faster and the satellite itself submerges deeper and deeper into the atmosphere at every revolution. When the satellite has descended to a certain level, where the heating from impact of air molecules on the frontal surface becomes great enough, the satellite burns out. For the purposes of ephemerides and for the prediction of the lifetime of the satellite, it is necessary to know how its orbital elements will be changed by the resistance of the air—supposing that we have some knowledge of the density of the air at the height where the satellite is moving, and of the drag coefficient of the satellite. Unfortunately, these data are not usually known with sufficient accuracy. But we can reverse this problem and search for a solution of how the air density could be determined from observed changes in size and shape of the orbit when the drag coefficient of the satellite is known. If we do not know this drag coefficient (which depends on the size, shape and mass of the satellite), we can still determine at least the gradient of the air-density. G. V. Groves published two valuable papers[1,2] last year, in which very accurate methods for such a determination have been developed. The only assumption made here, which could be accepted as a general approximation, is that air-density varies with height according to the relation:

$$\ln \frac{\rho}{\rho_{00}} = -\frac{1}{H_1}(h - h_{00}) + \frac{1}{H_2^2}(h - h_{00})^2 \quad (1)$$

where ρ_{00} is the density of the air at the height h_{00}, H_1 is the scale-height in the case of an isothermal atmosphere, and H_2 enables us to take account of the variation of atmospheric temperature with height. From the data of six different satellites with perigees between 180 and 650 km., Groves has found that, for $h_{00} = 200$ km.:

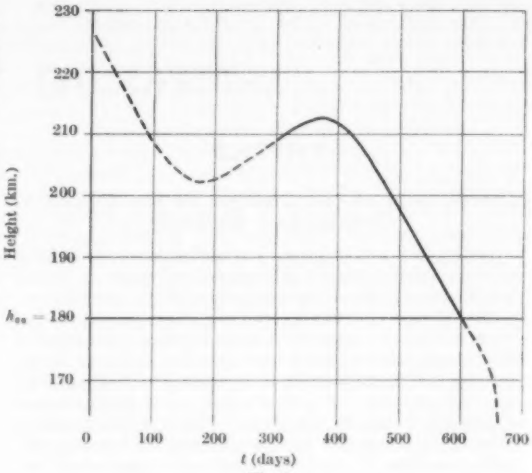

Fig. 1

$$\rho_{00} = 3{\cdot}8 \times 10^{-12} \times (1 \pm 0{\cdot}1)\ \text{gm./cm.}^{-3}$$
$$H_1 = 46 \pm 5\ \text{km.}$$
$$1/H_2^2 = (0{\cdot}028 \pm 0{\cdot}013)/46^2$$

In the second paper, methods have been developed for the determination of H_1 and H_2 without any knowledge of the drag coefficient. In this case, of course, the determination of ρ is not possible.

At the time when these papers were published, only a few not very accurate data of the orbits were available. Meanwhile, the third Soviet satellite, 1958δ2, was launched on May 15, 1958, and a great number of observations with improved instrumentation have provided accurate orbital elements and their changes. I have analysed all the data available so far. Nearly 100 sets of orbital elements have been taken into consideration. Not all have the same weight; it seems that the accuracy was improved after March 1959. For this reason I have restricted the analysis

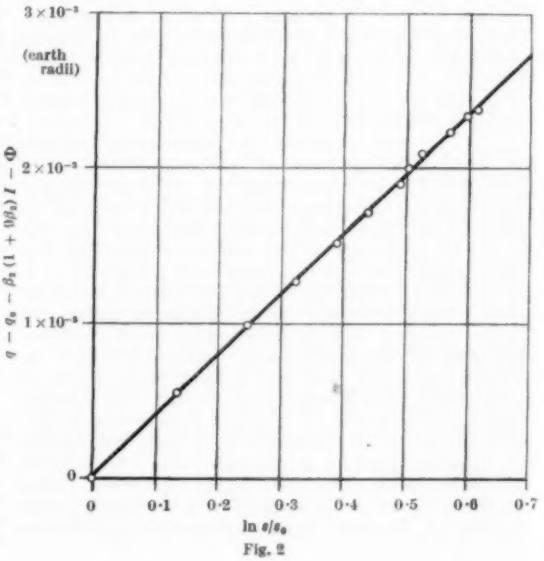

Fig. 2

in the present communication to the time interval between March 11, 1959, and January 5, 1960, that is, between 300 and 600 days after launching.

During this time-interval: (1) the perigee radial distance decreased from 1·03091 to 1·02824. The dependence of perigee radial distance q on time t could be approximated by the equation:

$$q = 1{\cdot}02137 + 0{\cdot}003713 \log (671 - t) \quad (2)$$

with a standard deviation $\pm 0{\cdot}9$ km.; (2) the eccentricity decreased from 0·08215 to 0·04191 in the same time-interval; (3) the perigee height changed in a more complicated manner, as shown graphically on Fig. 1; first, it rose from 208·7 km. to its second maximum of 212·2 km. at $t = 370$ days; after that date it was steadily decreasing and at the end of the time interval, $t = 600$ days, it was only 180·1 km.

These changes in the perigee height were produced by the motion of the angular perigee distance ω, which brought the perigee point above various latitudes of the Earth. The height-interval of 31·1 km. seems to be great enough to enable the determination of both constants H_1 and H_2. We used for this purpose smoothed orbital elements at twelve points where the perigee height was on the rising branch 210, 211 and 212 km., and then on the descending branch 212, 211, 210, 205, 200, 195, 190, 185 and 180 km. The computation was carried out according to the equation:

$$q - q_0 = \tfrac{1}{2}H_1(1 + 3\beta_2) \ln \frac{s}{s_0} + \beta_2 (1 + 9\beta_2) I + \Phi \quad (3)$$

where $\beta_2 = H_1^2/H_2^2$ and $s = qe/(1 + e)$. The integrals I and Φ depend on orbital elements and their changes with time and also on β_2. For details, one must refer to the original paper[2].

The result of my analysis is shown in Fig. 2, where $q - q_0 - \beta_2(1 + 9\beta_2)I - \Phi$ is plotted against $\ln s/s_0$. The straight line fitted to the twelve computed points by the method of least squares is in satisfactory agreement with equation 3, the mean error being only $\pm 2{\cdot}0 \times 10^{-5}$ earth radii ($= \pm 0{\cdot}13$ km.). The gradient of the line, $\frac{1}{2}H_1(1 + 3\beta_2)$, is equal to $\pm 388{\cdot}73 \times 10^{-5}$. With this value equation 3 has been recomputed to determine β_2; thus:

$$\beta_2 = 0{\cdot}024 \pm 0{\cdot}006$$

With this value, equation 3 has been used for the determination of H_1, and I have found:

$$H_1 = 46{\cdot}3 \pm 0{\cdot}7 \text{ km.}$$

As shown by the small probable errors, both values β_2 and H_1 are reliably determined. They agree well with the values obtained by G. V. Groves[1]. The scale-height is again 2–3 times greater than that derived from various theoretical models of the upper atmosphere. It is also noticeable that no seasonal effect was detectable during 300 days covered by this analysis, although during the same time the other artificial satellites with higher perigees were strongly influenced by changes of air density of long duration.

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RADIOPHYSICS

The Mesopause Region of the Ionosphere

In a recent communication, Gregory[1] suggested that the presence of free electrons at heights in the atmosphere between 80 and 90 km. may be due to the photo-ionization of dust which accumulates at the mesopause. Rocket measurements[2] have shown that the electron density at this height is about 1,000 el./c.c. on a normal day. This is also the order of magnitude of electron density required to account for the absorption of radio waves in the D region. It is of interest to see whether photo-ionization of the dust is able to give this observed electron density.

Noctilucent clouds are observed at the mesopause. While their composition is uncertain we arrive at an upper limit to the density of dust by assuming the clouds are composed of dust particles. From the luminosity and colour of the clouds Ludlam[3] estimated the particle density to be 0·01–1 particle per c.c. and the radius to be 1000 Å.–100 Å., the lower density corresponding to the larger radius.

Now the shortest wave-length of appreciable intensity of ultra-violet radiation from the Sun falling on the dust particles is about 2000 Å., except for the Lyman-alpha line (λ1216 Å.). The total Lyman-alpha flux[4] would only produce about 3×10^{-6} electron per c.c. per second by photo-ionization of the dust particles, whereas a rate of production of at least 0·06 electron per c.c. per second is required to give the observed electron density in this region[5]. Thus the Lyman-alpha photons can play no significant part in this process. A similar argument applies to short X-ray radiation.

The wave-length of 2000 Å. corresponds to a photon energy of about 6 electron-volts. The threshold energy for photo-electric ejection is about 3 electron-volts, so that the potential of the dust particles cannot exceed 3 volts. This potential determines the maximum positive charge on the particles and hence the maximum electron density. This turns out to be 2 el./c.c. for $r = 1000$ Å. and 20 el./c.c. for $r = 100$ Å., at least 50 times too small.

If the number density of particles is allowed to increase 50 times (for $r = 100$ Å.) to give the required electron density, a further difficulty arises. When an electron collides with a positively charged dust particle, there is an 80 per cent chance that the electron would be absorbed, so that the free electrons would disappear with a time constant of about 8 sec. Gregory, however, observes that the layer at 80 km. persists all night.

While it seems probable that the layer is associated with the mesopause, the suggestion that it is formed by photo-ionization of the dust particles appears to be untenable.

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Apparent Radio Radiation at 11-m. Wave-Length from Venus

In 1956 several preliminary communications reported the apparent reception of 11-m. radiation from the planet Venus[1]. In particular, one communication reported coherent or quasi-coherent radiation, designated Class II, which was also thought to originate from Venus. From further observations and subsequent analyses it now appears definite that these signals were not from Venus but were in all cases almost certainly interference of terrestrial origin.

Regarding the reports of the noise-type of radiation, designated Class I, a careful re-examination of the results indicates that the evidence is not sufficient to be sure that such radiation from Venus was observed. Attempts by others to detect the radiation have also been unsuccessful[2]. The validity of any deductions based on these observations, such as the rotation period of the planet, is, therefore, extremely doubtful.

Although some records, such as the one in Fig. 11 of a later article[3], show interferometer patterns which could be due to radiation from Venus, they are not conclusive. However, the fact that these records do suggest 11-m. radiation from Venus makes it difficult to rule out the possibility of such radiation completely. To determine the existence or non-existence of such radiation beyond any doubt, further observations are needed using a radio telescope of much higher resolution and better stability than was available in 1956.

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An Estimate of the Peak Sunspot Number in 1968

The smoothed peak sunspot number during the current cycle of solar activity attained a value in 1958 which has not been exceeded since accurate observations were begun more than 200 years ago. Conditions in the atmosphere of the Sun near the epoch of peak activity, and the closely related changes in the ionosphere, have already been the subject of comment[1].

It has been suggested that the uninterrupted rise in successive peak sunspot numbers since 1928, and its culmination in the unprecedented high peak of 1958, may indicate that the Sun is undergoing a long-term change and that the next peak, which will probably occur in about 1968, will be even higher than that of 1958. The opposing view is that, since the peaks of 1948 and 1958 were very high, the 1968 peak will be a very low one. These possibilities are of more than academic or scientific interest; they have a bearing on the effectiveness of the world-wide network of high-frequency radio-communication links, the successful operation of which depends on the reflexion of radio waves from the ionosphere. The operating conditions on such radio links are profoundly modified by changes in solar activity, and Hitchcock[2] has pointed out that, with the present-day overcrowding of the high-frequency radio spectrum, the occurrence of a solar cycle which attained only a low peak might lead to unforeseen difficulties.

It is of some importance, therefore, to estimate the probable limits within which the forthcoming peak sunspot number will lie. Obviously it is impossible to make a precise estimate; the present objective is merely to examine the purely statistical evidence contained in the sequence of twenty peak values which have occurred since 1750 and to decide whether there are any grounds for believing that the next peak will be either very high or very low. The cycle-matching technique described by Herrinck[3] has not been used because it cannot be safely extended beyond the end of the present cycle[4].

From a study of the lengths of sequences of uninterrupted increases and decreases in the peaks for successive cycles, it is possible to estimate the probability of occurrence of a sequence of three increases such as that which took place between the peaks of 1928 and 1958. The conclusion reached is that such an event is not an improbable one ($P \simeq 0{\cdot}12$), and it follows that its occurrence ought not to be interpreted as an indication of a long-term upward trend in solar activity. It is estimated on similar grounds that the probability of a fourth increase, leading to an even higher peak in 1968 than in 1958, is approximately 0·3.

The range of values within which the next peak will lie can be estimated from the frequency distributions of either the magnitudes of the twenty observed peaks or the differences between successive peaks. From such evidence it is found that there is a high probability that the 1968 peak will be between 110 and 160. The autocorrelation function for the twenty peaks (R) since 1750 has been evaluated, but the correlation coefficients differ significantly from zero only for R_n, R_{n+1} and R_n, R_{n+2}. The regression lines for these two cases have been used to forecast the peak in 1968; and the values obtained, with their standard errors of estimate, are 154 ± 38 and 97 ± 36 respectively. These values are consistent with the range of values (110–160) based on the frequency distributions referred to earlier.

The various independent estimates of the next peak have been combined, taking into account their respective probabilities and making an allowance for the fact that the estimates are based on a sample of only twenty values. It is concluded that there is a probability of at least 0·75 that the next smoothed peak sunspot number, which will occur about 1968, will be in the range 110–160. Thus it seems reasonable to expect that ionospheric and radio-communication conditions during the 1964–74 solar cycle will be roughly comparable with those which occurred during the 1934–44 and 1944–54 cycles.

This communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research; the work will be described more fully elsewhere.

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METEOROLOGY

Wind Profile in Thermally Stratified Flow

THE variation of horizontal wind-speed u with height z in the air flowing over uniform ground is, in conditions of neutral equilibrium, well represented by the expression :

$$\frac{\partial u}{\partial z} = \frac{u^*}{kz} \tag{1}$$

where u^* is the 'friction velocity', defined as $u^{*2} = \tau/\rho$, τ being the horizontal shearing stress caused by the wind and ρ the air density. k is von Kármán's universal dimensionless constant. This relationship, well based theoretically and amply verified by experiment (see, for example, Sheppard[1]), is expected to apply at all heights within the layer of constant shearing stress.

Attempts to extend this formulation to the case of thermally stratified flow have, however, met with severe difficulties, and up to the present time such treatments as have been given, mainly of a quasi-theoretical or frankly empirical nature, have met with only partial success and this limited to small departures from the neutral state.

It will be shown here that it is possible to derive a formal solution to the problem devoid of all arbitrary constants, expressing the variation of wind with height uniquely in terms of the shearing stress and the vertical heat flux H associated with the thermal stratification. No restriction is imposed on the magnitude of these latter quantities, and the result is applicable at all heights within which τ and H remain constant.

In a steady state of turbulence, the rate of viscous dissipation of turbulent kinetic energy at a given point, ε per unit volume of air, is represented by :

$$\varepsilon = \tau \frac{\partial u}{\partial z} + \frac{gH}{c_p T} \tag{2}$$

g is the acceleration of gravity, c_p the specific heat of air at constant pressure and T the temperature of the air. The terms on the right-hand side of (2) are, respectively, the rate of working of the shearing stress on the mean rate of strain, and the work done per unit time against gravity by buoyancy.

I now introduce a new height variable X, defined according to the equation :

$$\tau \frac{\partial u}{\partial X} = \tau \frac{\partial u}{\partial z} + \frac{gH}{c_p T} \tag{3}$$

X, which will be seen intuitively to be a function of z, τ and H, thus permitting the combination of contributions from both sources of energy in the pseudo-shearing stress term $\tau\, \partial u/\partial X$.

A similarity assumption is now made that :

$$\frac{\partial u}{\partial X} = \frac{u^*}{kX} \tag{4}$$

The hypothesis here is that, just as in (3), the new height X is able to accommodate in the one term the energy supply both from the mean motion and from buoyancy, so in (4) it will preserve, in conditions of thermal stratification, the linear inverse relationship between wind shear and height characteristic of simple shear flow. It must be emphasized that, at this stage, (4) is no more than a reasonable assumption the validity of which remains to be assessed by the accuracy of its consequences now to be derived.

Elimination of u between equations (3) and (4) leads to the differential equation :

$$1 = \frac{\mathrm{d}X}{\mathrm{d}z} - \frac{X}{L} \tag{5}$$

where L, of dimension length, has been introduced to represent $-\dfrac{c_p \rho T u^{*3}}{kgH}$. (The notation here follows that of Monin and Obukhov[2].)

Integration of (5), invoking the condition that as $L \to \infty$, $X \to z$, yields :

$$X = L\{\exp(z/L) - 1\} \tag{6}$$

from which, after a little manipulation,

$$\partial u/\partial z = u^*/kL\ \{1 - \exp(-z/L)\}^{-1} \tag{7}$$

A recent attempt, by Monin and Obukhov (*loc. cit.*), to solve the problem now under discussion proceeds by dimensional arguments to postulate that :

$$\frac{\partial u}{\partial z} = \frac{u^*}{kz}\left\{1 + \alpha_1\left(\frac{z}{L}\right) + \alpha_2\left(\frac{z}{L}\right)^2 + \ldots.\right\}$$

where the coefficients remain to be determined by experiment. The present formulation lends support to this hypothesis, as expansion of the exponential term in (7) shows. Furthermore, it follows from (7) that :

$$1 + \alpha_1\left(\frac{z}{L}\right) + \alpha_2\left(\frac{z}{L}\right)^2 + \ldots. = \frac{z}{L}\left\{1 - \exp(-z/L)\right\}^{-1}$$

Integration of (7) between the levels z_1 and z_2 gives :

$$u_2 - u_1 = \frac{u^*}{k} \ln\left[\frac{1 - \exp(z_2/L)}{1 - \exp(z_1/L)}\right] \tag{8}$$

A similar relation applies to levels z_3 and z_4, whence division eliminates u^*/k to yield :

$$\frac{u_2 - u_1}{u_4 - u_3} = \ln\left[\frac{1 - \exp(z_2/L)}{1 - \exp(z_1/L)}\right] \Big/ \ln\left[\frac{1 - \exp(z_4/L)}{1 - \exp(z_3/L)}\right] \tag{9}$$

By numerical, or preferably graphical, interpolation equation (9) then permits the determination of L from observed winds, whence substitution of the appropriate L in equation (8) yields u^*. H, the heat flux, can then be determined from the defining expression for L.

The extensive wind observations of Monin and Obukhov (*loc. cit.*) have been analysed within the framework of the present analysis, and yield remarkably consistent values of L and u^* over the whole height-range of 0·5–15 metres, and over a wide range of stabilities. The relevant values of z/L vary from $-7{\cdot}5$ to $3{\cdot}75$. Furthermore, u^* so determined accords almost exactly with its value calculated in an entirely different manner (involving the use of drag coefficient at the lowest level of wind measurement where the analysis shows the effects of buoyancy to be negligible). Equation (8) yields an explicit formulation for the 'roughness length', determinations

from which show excellent agreement. In brief, it may be said that the present indications are that the law of wind variation contained in equation (8) promises to be capable of universal application without restriction as regards stability, and at all heights within the layer of constant heat flux and shearing stress.

Analysis of other observational material is now in hand, and an experimental programme in progress designed to assess the validity of the present treatment by comparison of its predictions against values of the shearing stress and heat flux determined directly by the eddy-correlation method.

A full account of the work summarized here, together with that now being undertaken, will be published elsewhere in due course.

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GEOLOGY

Uraninite and Thorianite

Wasserstein[1] suggested that the generation by radioactive decay of Pb^{4+} of smaller ionic radii within the crystal lattice of uraninite caused a shrinkage in the unit cell proportionate to the geological age and the shrinkage was of the order of 0·0025–0·0041 Å. per hundred million years. The anomaly in the relation of cell dimensions of Bisundni and Gaya uraninites with the age, reported by Holmes[2], was explained by Wasserstein[1] by classifying uraninites into two different types—α-type for Bisundni uraninite and γ-type for Gaya uraninite, the latter being apparently anomalous and requiring heat treatment under oxidizing conditions in order to reduce the cell size to correspond to that of an α-type analogue. Wasserstein did not, however, state the temperature and period of heating and the conditions under which the cell size of γ-uraninite was reduced to correspond to age values consistent with those of the α-type.

A number of specimens of uraninite from Bisundni and Gaya from the collection in the Indian Museum made by H. Crookshank[4] and G. H. Tipper[5], and thorianite from Ceylon by A. K. Coomaraswamy[6], were used for the present study. The cell dimensions of Bisundni uraninites (a_0 5·436–5·440 Å.) and Gaya uraninites (a_0 5·459–5·467 Å.) are different from those reported by Wasserstein[1] (5·448 Å. for Bisundni and 5·481 Å. for Gaya). A thoria correction[1] of −0·0013 Å. for each percentage thorium oxide when ($ThO_2 + UO_2$) totals 100 per cent will reduce the cell size of Bisundni uraninite by 0·002 Å. (a_0 5·436 Å. mean value) and Gaya uraninite by 0·017 Å. (a_0 5·445 Å. mean value) if the ratio of uranium oxide to thorium oxide is calculated on the basis of Holmes's analysis (Table 1).

The finely powdered uraninite (a few mgm.) was heated at 800° C. in an open silica boat (1) within an electric muffle furnace and (2) also within a closed silica retort tube (of 2-cm. diameter placed inside an electric tube furnace at 800° C.) which was continuously evacuated to maintain a vacuum of the order of 10^{-3} mm. of mercury.

Table 1

Indian Museum No. and locality	Uraninite (UO_2 a_0)	Heated at 800° C. for 30 min. in vacuum	Heated at 800° C. for 15 min. in a muffle furnace
Uraninite, Bisundni (*ex* Holmes (ref. 2)). Age 735 (± 5) m.y., U = 72·9, Pb = 7·95, Th = 1·4 per cent			
R 763 Bisundni, Ajmer-Merwara	5·440	UO_2 major a_0 5·437, plus *X* scarce	U_3O_8 major, plus *X* minor
S 128 Bisundni mine, Ajmer-Merwara	5·436	UO_2 major a_0 5·433, plus *X* minor	U_3O_8 major, plus *X* minor
Uraninite, Gaya (*ex* Holmes (ref. 2)). Age 955 (± 40) m.y., U = 64·3, Pb = 8·92, Th = 8·12 per cent			
N 811 Pichchli, Gaya	5·459	UO_2 major a_0 5·450, plus *X* scarce	U_3O_8 major, plus UO_2 minor a_0 5·455, plus *X* scarce
L 301 Abraki, Singar, Gaya	5·462	UO_2 major a_0 5·452, plus *X* scarce	U_3O_8 major, plus *X* minor
L 176 Singar, 6 miles west-north-west of Abraki, Gaya	5·467	UO_2 major a_0 5·456, plus *X* scarce	U_3O_8 major, plus UO_2 minor a_0 5·461, plus *X* scarce
Thorianite, Ceylon (Nag and Mousuf (ref. 7)), U = 21·2, Th = 60·2 per cent. Holmes (ref. 13), age 490 m.y., U = 11·67, Pb = 2·30, Th = 67·03 per cent			
J 658 Thorianite from a gem sand near Kondurugala, Balangvda Dt., Ceylon	Thorianite $(Th,U)O_2$ a_0 5·575	Thorianite a_0 5·556, plus a few faint extra lines	Thorianite (powder lines sharp) a_0 5·575, plus a few faint extra lines
J 659 Thorianite, Bambarabotuwa, Ceylon	Thorianite a_0 5·573	Thorianite a_0 5·555, plus extra lines	Thorianite (powder lines sharp) a_0 5·573, plus extra lines

The cell size was determined with an accuracy of ± 0·003 Å. using aluminium as internal standard with 114·59 mm. diameter Philips' powder camera having two fiducial marks, and copper *Kα*-radiation (λ = 1·5405 Å.).

Brooker and Nuffield[8] observed a shrinkage of the cell size of uranium dioxide (on heating in vacuum at 900° C. for 30 min.) of the order of 0·02–0·05 Å. depending on the degree of oxidation, the ratio of U^{4+} to U^{6+} in the original lattice, and reported the formation of the unknown compound *X* (U_3O_8 ?). In the present study (Table 1) the shrinkage of the cell size of uranium dioxide is followed by a close doubling of the higher-angle diffraction lines (development of an additional phase) and the formation of the compound *X*. The oxidation of uraninite out of contact with oxygen suggests that in the oxygen-rich lattice of natural uraninite the excess of oxygen occupies the available interstitial positions (½ 0 0) in six-fold co-ordination with uranium[9,10], and this shrinkage of cell size implies simultaneous replacement of U^{4+} cations (1·05 or 0·97 Å.) by the U^{6+} cations (0·80 Å.), that is, the substitution of cations of smaller ionic radii and higher charge, is preceded by readjustment of interstitial anions in the fluorite-type lattice (space group $Fm3m$). The cell size of 5·47 Å. for synthetic uranium dioxide decreases to 5·39 Å. for $UO_{2\cdot6}$, but the structure is preserved[8] even when the alteration of U^{4+} : U^{6+} : O ratio apparently extends up to about $UO_{2\cdot6}$. The progressive reduction of the cell size of uranium dioxide due to the substitution of Pb^{4+} (0·84 Å.) for U^{4+} within the lattice with time (which has not been evaluated but only visualized by Wasserstein[1,2]) is likely to be quite negligible compared to the more pronounced shrinkage due to alteration of U^{4+} : U^{6+} : O ratio in the oxygen-rich lattice of natural uraninite.

Moreover, lead in lower valency state (Pb^{2+} 1·21 Å.) is a greater possibility[11].

Wasserstein's proposed classification of thorianite into γ-type may be interpreted from the observed evidence on synthetic members of the series ($U_xTh_{1-x}O_2$) by Anderson *et al.*[12]. On high-temperature vacuum heating the type of interaction[12] between uranium and interstitial oxygen in the original lattice alters with the conversion of U^{4+} to U^{6+} and consequent shrinkage of the unit cell (Table 1); Th^{4+} ions do not react because of their reluctance to donate electrons.

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Calcutta. Jan. 2.

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Silicon in the Metal Phase of Enstatite Chondrites

I HAVE recently measured the lattice parameters of the metal phases from a number of chondrites. In five common varieties the kamacite lattice parameter was within the range 2·8682 ± 0·0005 Å. This corresponds to an average of 5 per cent nickel in solid solution[1]. Owen and Burns[1] found that the kamacite lattice parameters from 15 meteoritic irons were within the range 2·8686 ± 0·00015 Å. This is in good agreement with the above result, and indicates the presence of about 6 per cent nickel. I also examined the kamacite from 6 enstatite chondrites. In these, the lattice parameters were found to be abnormally low, and below that of pure iron (Table 1). The metal phases of these chondrites had previously been analysed and found to contain normal amounts of nickel—between 6 and 8 per cent. Since the solid solution of nickel 'increases' the lattice parameter of pure iron, it was inferred that appreciable amounts of some other component were also present in solid solution and that this component had caused the lattice parameter to contract.

A process of elimination led to the conclusion that the additional component was silicon. This is the only element which forms extensive solid solutions with iron, causing marked contraction of the lattice parameter, and at the same time, occurs in sufficient quantities in chondrites to produce the observed contraction. A literature survey revealed that 2 (atomic) per cent of silicon had previously been recorded in the metal phase of the enstatite chondrite Blithfield[2]. Furthermore, in the metal phases of other enstatite chondrites—Khairpur[3], Daniels Kuil[3] and Saint Marks[4]—the analysts have commented upon an apparent 'excess' of silica, but could not account for its origin. Kamacite from three of the meteorites has been examined by X-rays. The lattice parameters were substantially less than that of pure iron, and it therefore seems highly probable that the excess silica found by the analysts was derived from elemental silicon in solid solution. The analytical results in Table 1 have been recalculated on this assumption.

Table 1. SOME PROPERTIES OF KAMACITE FROM ENSTATITE CHONDRITES

Reference	Meteorite	Atoms per cent nickel in kamacite	Lattice parameter of kamacite Å.	Atoms per cent silicon in kamacite from X-ray data	Atoms per cent silicon in kamacite from chemical data
2	Blithfield	6·4	2·8657	5	2·0
3	Daniels Kuil	6·2	2·8655	5	3·3
9	Hvittis	7·6	2·8655	5	
10	Indarch	6·7	2·8619	10·5	
3	Khairpur	7·0			1·9
11	Pillistfer	8·4	2·8652	6·5	2·6
4	Saint Marks	6·4	2·8682	9	18
12	Kamacite from five ordinary chondrites	Average 5	2·8630 ± 0·0005		
1	Kamacite from 15 meteoritic irons	6·2	2·8686 ± 0·00015		
	Pure iron	0	2·8665		

In all enstatite chondrites studied, the only metal phase present was kamacite.

A sample of kamacite was magnetically separated from a large sample of the Pillistfer enstatite chondrite and purified by grinding, repeated fusion with sodium hydroxide and washing on a superpanner. Chemical analysis of the pure kamacite has indicated the presence of approximately 2·6 atoms per cent of silicon. X-ray examination of this sample again revealed a contraction of lattice parameter compared to iron.

The variation of lattice parameters of iron–silicon solid solutions as a function of composition is well known[5]. If one makes the reasonable assumption that the relative variation is not greatly modified by the presence of 6–8 per cent of nickel in solid solution, it is possible to estimate the silicon content of kamacite from the difference between the observed lattice parameter and that of a normal iron–nickel solid solution of the relevant composition. These estimates are set out in Table 1.

The above results indicate that silicon is an important component of the metal phase of enstatite chondrites, the amounts present ranging between 2 and 18 atomic per cent. This occurrence is consistent with the highly reduced state of enstatite chondrites, which contain iron-free silicates and reduced chromium, calcium and phosphorus minerals (daubreelite, oldhamite, schreibersite).

Ringwood[6,7] and MacDonald and Knopoff[8] have independently suggested the presence of substantial amounts of silicon in the Earth's core. Occurrence of silicon in the metal phase of enstatite chondrites is very relevant to this hypothesis. A detailed discussion of the present results and their bearing upon this hypothesis will be published elsewhere.

I gratefully acknowledge the gift of meteorite specimens by Mr. O. Chalmers (Australian Museum), Dr. H. B. Wiik (Geological Survey of Finland),

Dr. K. Fredriksson (Geological Survey of Sweden), and Mr. K. R. Dawson, Geological Survey of Canada.

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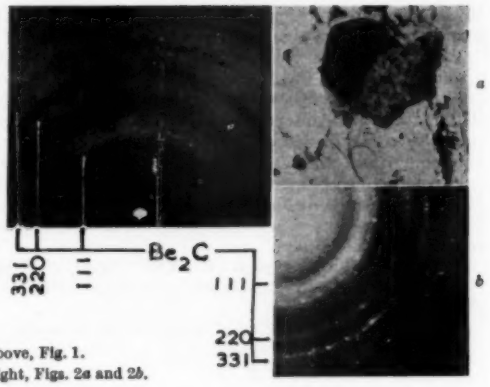

Above, Fig. 1.
Right, Figs. 2*a* and 2*b*.

METALLURGY

Formation of Beryllium Carbide during the Corrosion of Beryllium in Carbon Monoxide and in Carbon Dioxide Gas

Previous workers[1] have concluded from a comparison of the reaction between beryllium in dry carbon dioxide at 650° C. and in dry oxygen at 650° C. under kinetic conditions that the higher gain in weight of the specimen in carbon dioxide was due to the formation of beryllium carbide, which rendered the beryllium oxide non-protective. However, no metallographic evidence for the deposition on to the specimen of carbon, either as elementary carbon or as carbide, was given to support their hypothesis.

More recently (Jepson, W. B., and Antill, J. E., private communication), experiments designed to investigate the corrosion behaviour of beryllium using radioactive carbon monoxide and carbon dioxide under static conditions have shown that carbon (as the isotope carbon-14) is indeed deposited on the beryllium. Two typical specimens from this work have been examined by optical and electron microscopy and electron diffraction at the Atomic Weapons Research Establishment, Aldermaston, in order to locate the deposited carbon and to investigate whether beryllium carbide was formed.

The beryllium specimens were cut from rolled sheet 0·031 in. thick produced from French Flake beryllium. They were chemically polished and outgassed before insertion into the reaction vessel.

The first of the two specimens was heated at 700° C. in carbon monoxide and in this case spalling of the reaction product occurred. The uptake of carbon was measured from the decrease in count-rate of the gas, and the total gain in weight of the specimen was calculated from the measured volume of reacting gas.

A taper section through a piece of the specimen showed a well-defined boundary between the beryllium metal and the hard grey-looking scale on the surface, and immediately beneath this layer occurred a region some 100μ in depth of extensive cavitation which, by comparison with a corresponding section of as-received metal, was concluded to have been produced during the corrosion.

A reflexion electron diffraction pattern from the specimen surface is illustrated in Fig. 1. Measurement of the rings showed the presence of beryllium oxide, a hexagonal structure with $a = 2{\cdot}2679$ Å. and $c = 4{\cdot}380$ Å.[2], and in addition, three extra rings not attributable to beryllium oxide. Using the oxide rings for calibration these extra rings were found to have d-spacings of 2·51 Å., 1·53 Å. and 1·31 Å. respectively. No similar patterns have been presented in any previous corrosion work on beryllium. The crystal structure of beryllium carbide (Be_2C) is reported from X-ray observations[3] as of the anti-fluorite type, that is, cubic with $a = 4{\cdot}33$ Å. The first three carbide diffractions are given as (111), (220) and (311) with d-spacings of 2·51 Å., 1·53 Å. and 1·31 Å. respectively. The close agreement between the X-ray results and the present electron diffraction results is considered to be direct evidence for beryllium carbide having been formed during corrosion in carbon monoxide.

Fragments of the corrosion product were stripped from the specimen using plastic films and the extraction replicas examined in the electron microscope. Particles ranging in size from 0·1 to 10μ were observed adhering to the replica. An electron diffraction pattern (Fig. 2*b*) from the edge of one particle of about 5μ diameter, Fig. 2*a* (× 4,000), is similar to Fig. 1 and clearly shows the presence of beryllium oxide and beryllium carbide. Some extracted particles gave only beryllium oxide diffractions, but no particles consisting entirely of beryllium carbide were observed.

Examination of a specimen subjected to carbon dioxide at 700° C. again gave diffraction patterns showing the formation of beryllium oxide and beryllium carbide.

From these experiments it is concluded that beryllium carbide is formed together with beryllium oxide during the reaction at 700° C. of beryllium with static carbon monoxide gas and also with static carbon dioxide gas, and that the carbide particles are dispersed within the oxide layer.

Thermodynamical results[4] indicate that free carbon could also be formed during the above reactions, although carbon was not identified in the present electron diffraction investigation. If, therefore, carbon is present in the reaction products it must be disseminated in such a way that there is an insufficient quantity accessible to the electron beam for detection.

Further work is in progress to study the diffusion of carbon into beryllium and the effect of the presence of the carbide phase on the mechanical properties of the metal.

I wish to thank Dr. W. B. Jepson and Mr. R. J. Hussey of the Chemistry Department, University of Exeter, and Dr. J. E. Antill of the Metallurgy Division, Atomic Energy Research Establishment, Harwell, for providing the beryllium corrosion specimens. This work was carried out in the Crystallography Section of the Metallurgy Branch, Atomic Weapons Research Establishment, Aldermaston, under the direction of Dr. A. Moore.

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Photo-stimulated Emission of Exo-electrons from the Surface Layer of Amphoteric Metals reacting with Concentrated Sodium Hydroxide or Potassium Hydroxide

While studying the influence of liquids[1] on the tribo-excited emission phenomena of exo-electrons (Kramer effect[2]) from metals, we have found that the amphoteric metals like aluminium, zinc and tin as well as brass and some soldering alloys containing tin give a comparatively strong emission of exo-electrons when irradiated with visible light, after the freshly abraded surface is sprayed with strong concentrated sodium hydroxide or potassium hydroxide.

Aluminium gives this strong emission even when the surface is not abraded.

This emission can also be measured from abraded cadmium. In this case, we think the emission is due to traces of zinc impurity in the cadmium.

The intensity of measured photo-stimulated emission decreases with the thickness of the covering layer of sodium hydroxide or potassium hydroxide. This seems to be due to the absorption of exo-electrons from the metal-solution interface region.

In darkness no significant emission is detected.

The preliminary measurements seem to show that each of the amphoteric metals has a different 'decay constant' for the emission from their reacting surface layers.

The emission was measured in atmospheric air with the aid of a point counter with a grid. The pulses in the counter could be completely suppressed by a retarding potential applied between the grid and the reacting metal[3].

The observed effect is not due to the exothermic character of the reactions. To prove it, the reactions of abraded zinc and aluminium with concentrated hydrochloric acid have been examined using the same experimental conditions. In neither case was any photostimulated emission of exo-electrons observed.

The effect could not be observed for the metals iron, copper, bismuth, nickel, lead and magnesium when they were tested under the same experimental conditions.

Magnesium, which is known to give very intensive emission of exo-electrons under visible light after the abrasion of the surface (like aluminium) but which is known not to be amphoteric, shows a remarkable decrease of emission intensity after the emitting surface is sprayed with concentrated sodium hydroxide or potassium hydroxide. Aluminium, tin and zinc in contrast always show a strong increase under those conditions.

A detailed report will be published in *Acta Physica Polonica*.

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Thin Films of Silver–Cadmium Alloy

We have undertaken a detailed electron diffraction study of thin films of silver–cadmium alloy obtained by evaporating the constituent metals consecutively in vacuum. Films of various compositions have been formed in this way and their phases and structures identified.

Near equi-atomic composition of this alloy system a crystallographic transformation has been reported by many workers employing X-ray diffraction and other methods to occur in the bulk state[1]. By such studies it has been established that, in bulk state, the low-temperature β^1-phase (body-centred cubic ordered) structure changes to ξ-phase (closest-packed hexagonal) around 250° C., although the exact transformation temperature is a matter of controversy. Employing high-temperature electron diffraction technique, we have tried to investigate this transformation with the view of determining the exact transformation temperature in the case of thin alloy films. Careful and repeated observations with well-homogenized films about 500 Å. thick, giving a characteristic pattern of pure β^1-phase (body-centred cubic structure) at room-temperature, failed to reveal any change at all in the phase up to a temperature as high as 300° C. The study could not be extended to higher temperatures because of the rapid volatilization of cadmium from the alloy films, leaving the films less rich in cadmium and consequently changing to α-phase.

The details of the investigation will be published elsewhere.

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CHEMISTRY

Preparation of Tritiated Water Samples by Distillation

In many experiments using tritium as a tracer it is necessary to prepare a sample of pure water from organic material. During measurements of total body water using tritiated water in a dilution technique we have obtained pure water samples from urine by distillation. The urine is placed in a small vessel (Fig. 1) the bulb of which is put in an oil-bath maintained at 110° C. The distillate collects in the

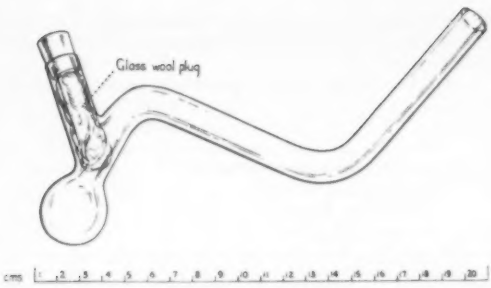

Fig. 1. Distillation tube

bend of the side-arm, which is cooled by a piece of wet paper or cloth. The glass-wool plug prevents urine frothing over into the side-arm. This technique has proved more effective and convenient than decolorizing with activated charcoal.

However, we were concerned that there might be a considerable isotope effect in the evaporation of ordinary and tritiated water, leading to the initial distillate being weak in tritium. The apparent 10 per cent difference in the molecular weights of water and HTO will be effectively reduced if water is associated at its boiling point, but the exact degree of association seems uncertain[1]. For a simple system containing water and HTO the relative evaporation rates of the two components would be expected to equal the ratio of the vapour pressures. This ratio has been measured by Price[2] between 25° and 80° C. Extrapolation of his results indicates a vapour pressure difference of about 4 per cent at the boiling point of water and a difference of boiling point of 1–2° C.

As the fractionation of liquids with different boiling points depends upon the exact conditions of distillation, particularly the reflux ratio, we distilled a water sample containing a known activity of HTO in our apparatus, collecting the distillate in four approximately equal fractions. The activities of all fractions and an aliquot from the original sample were measured by liquid scintillation counting. The major source of error was probably that associated with dispensing, as counting statistics contributed only about 0·1 per cent. The results are set out in Table 1.

Table 1

Specimen	Relative specific activity
Original sample	100
First quarter of distillate	99·7
Second quarter of distillate	99·7
Third quarter of distillate	100·3
Fourth quarter of distillate	100·4

It would appear that, with our apparatus, little separation of the isotopes occurs, and it is permissible to distil and measure only a fraction of the initial sample.

We are indebted to Dr. G. Boyd for suggestions regarding the distillation vessel.

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Oxidation of Beryllium in Carbon Dioxide and in Carbon Monoxide

The metal beryllium has been suggested as a possible canning material in the advanced gas-cooled thermal reactor, so that its oxidative behaviour at elevated temperatures in carbon dioxide, carbon monoxide and mixtures of these two gases is of some technological importance. Published work on the oxidation of beryllium in carbon dioxide is limited to the investigation of Munro and Williams[1], which covered the temperature range 500–700° C.; here the course of the oxidation was followed by intermittent weighing, the sample being cooled to room temperature for each measurement. The purpose of this communication is to report briefly some of the results of a recent study of both the chemistry and the kinetics of the reaction between French Flake beryllium and carbon dioxide, carbon monoxide and their mixtures (usually at a pressure of 10 cm.) and at temperatures in the range 500–750° C. The samples were chemically polished before use.

With the aid of a specially developed radioactive tracer technique using carbon-14 labelled carbon dioxide, it has been established that when beryllium is oxidized in carbon dioxide, the following reactions occur:

$$Be + CO_2 = BeO + CO \quad (1)$$

$$2Be + CO_2 = 2BeO + C \quad (2)$$

There is no evidence for reaction[2] of deposited carbon with carbon dioxide:

$$C + CO_2 \rightleftharpoons 2CO \quad (3)$$

or for the reaction:

$$Be + CO_2 = BeO + C + \tfrac{1}{2}O_2 \quad (4)$$

even though this is thermodynamically possible[3,4]. Chemical analysis of the reaction product shows that some 38 per cent of the deposited carbon is combined with beryllium as beryllium carbide. It is believed that the latter is formed after the carbon has been deposited, by the reaction:

$$2Be + C = Be_2C \quad (5)$$

rather than by:

$$4Be + CO_2 = 2BeO + Be_2C \quad (6)$$

The overall rate of reaction (oxide formation and carbon deposition) has been studied on a vacuum microbalance and at temperatures up to and including 700° C.; the rate of oxidation continuously decreases with time (Fig. 1) to reach a very small value after long periods, the rate after 300 hr. varying from 0·01 μgm./cm.² hr. at 500° C. to 0·07 μgm./cm.² hr. at 700° C. Oxidation is thus protective over the range 500–700° C., in general agreement with the results of Munro and Williams[1]. At 750° C., on the other hand, the rate of oxidation first decreases and then increases with time, indicating a breakaway reaction.

The amount of deposited carbon, both elementary and combined, in the oxide film is small, varying in a somewhat irregular manner with temperature from 1·8 μgm./cm.² at 550° C. to 11 μgm./cm.² at 750° C.

When the carbon dioxide is admitted to the outgassed sample at reaction temperature there is (see Fig. 1) a very rapid initial weight gain (which as a fraction of the total weight gain after 300 hr. varies

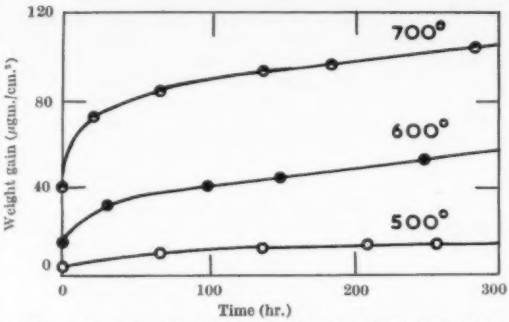

Fig. 1. Oxidation of beryllium in carbon dioxide at 500°, 600° and 700° C. The gas was admitted to the preheated sample

from 28 per cent at 500° C. to 41 per cent at 700° C.), and it appears that most of the carbon deposition occurs over this initial period; if, however, the beryllium was heated in carbon dioxide from room to reaction temperature, the initial gain in weight was no longer obtained, carbon deposition occurred over a longer period, and the amount deposited was less. The oxidation curves corresponding to these two differing modes of heating up the sample approach each other with increasing time.

For the oxidation of beryllium in carbon monoxide, the reaction :

$$2Be + CO = Be_2C + \tfrac{1}{2}O_2 \qquad (7)$$

is excluded on thermodynamic grounds[3,4] so that there are only the possibilities :

$$Be + CO = BeO + C \qquad (8)$$

and :

$$3Be + CO = BeO + Be_2C \qquad (9)$$

Since there are no volatile reaction products, kinetic measurements do not distinguish between reactions 8 and 9 and it is necessary to resort to chemical analysis of the reaction product. This shows that 15 per cent of the deposited carbon is chemically combined with beryllium as carbide and is probably formed by reaction 5 rather than reaction 9. There was no evidence for the decomposition of carbon monoxide on the surface, to deposit carbon and evolve carbon dioxide (reaction 3). For a given temperature, the rate of oxidation of beryllium in carbon monoxide is considerably greater than in carbon dioxide and a further important difference is that at 550° C. and above, the oxidation of beryllium in carbon monoxide is non-protective, the reaction product spalling from the sample during the run.

For oxidation in mixtures of carbon monoxide–carbon dioxide there is the possibility of reaction with either one or both of these gases, but runs at 650° C. in mixtures containing up to 7·5 per cent carbon monoxide showed that the oxidation followed the same course as in carbon dioxide alone. Supplementary measurements at a number of temperatures suggest that there exists a critical concentration of carbon monoxide above which the reaction changes from one with carbon dioxide to one with carbon monoxide, the rate of carbon deposition, and hence the rate of oxidation, then markedly increasing. At 700° C. this critical concentration of carbon monoxide is about 88 per cent by volume.

A detailed description and discussion of these results will be published elsewhere. We are grateful to Dr. J. E. Antill for several helpful discussions, and wish to acknowledge the financial support which this work has received from the United Kingdom Atomic Energy Authority.

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Behaviour of Some Aldehydes on a Sulphonated Polystyrene Resin

5-Hydroxymethyl 2-furaldehyde is a well-known product from the browning reaction[1] between certain sugars and amino-compounds. In the course of its isolation from such a reaction mixture it was assumed that it would be easily eluted, together with the unreacted sugar present, from a column of 'Zeokarb 225 [H⁺]' resin. Instead it was found that the volume of 0·3 *N* hydrochloric acid required to elute it was approximately 0·6 of that required to elute D-glucosamine. Passage of 2-furaldehyde and salicylaldehyde down the same column (Fig. 1) revealed that these were even more strongly absorbed. Since 5-hydroxymethyl 2-furaldehyde showed no evidence of behaving as a base on paper ionophoresis in either 0·75 *M* formate buffer *p*H 2 or 0·3 *N* hydrochloric acid, the explanation for its retention must lie in some other mechanism of interaction with this sulphonated polystyrene resin.

One possibility is that the aldehydes form weak addition compounds with the sulphonic acid function. By analogy with the reaction between benzaldehyde, benzene sulphonyl chloride and sodium cyanide,

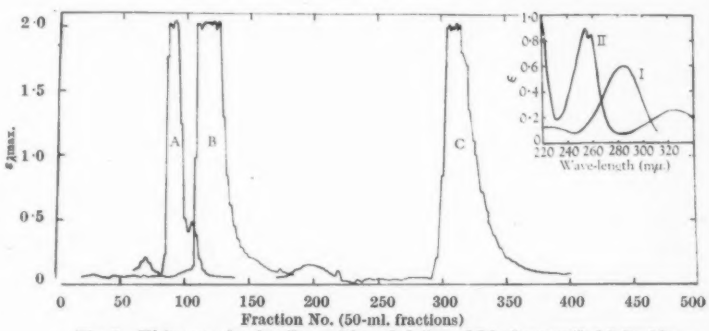
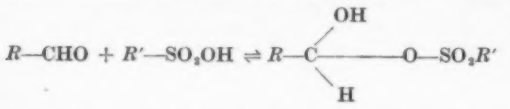


Fig. 1. Histogram showing the position of elution of 5-hydroxymethyl 2-furaldehyde (*A*), furfuraldehyde (*B*) and salicylaldehyde (*C*) from a column of sulphonated polystyrene resin ('Zeokarb 225'). Inset are the absorption curves of 5-hydroxymethyl 2-furaldehyde (I) and salicylaldehyde (II)

which afforded α-cyanobenzyl benzene sulphonate[2], this addition compound could be formed thus:



Another factor influencing the absorption of the aldehydes could be van der Waals adsorption forces, since it is known that compounds containing aromatic residues are adsorbed on polystyrene ion-exchange resins[3–5]. 'Amberlite *IR* 120 (H^+)', which is equivalent to 'Zeo-Karb' 225 [H^+]', has been used[6] to separate phenol, *p*-cresol and 4-tert. butyl phenol. Gabrielson and Samuelson[7] have investigated the adsorption of aldehydes and ketones on 'Amberlite *IRA*–400' (bicarbonate form), which is an anion exchanger of the strongly basic type. They reported that salicylaldehyde and vanillin were strongly absorbed, whereas formaldehyde, acetaldehyde and 2-furaldehyde were eluted almost quantitatively. In this case absorption was attributed to the acidic character of the two aromatic aldehydes.

The unexpected property of derivatives of 2-furaldehyde may prove useful not only in the identification of intermediates in the browning reaction but also those products of acidic degradation of sugars which form the basis of so many colour reactions for the quantitative determination of sugars.

One of us (K. M.) thanks Glaxo, Ltd., for the award of a scholarship.

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Symmetry of Insulin Dimers and Hexamers

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This conclusion was strengthened by Patterson studies of the wet type *A* insulin sulphate crystals[5]. The position of the highest non-origin peak in the three-dimensional Patterson function is that of a pseudo-origin in each of two Patterson projections—that is, the distributions of peaks about this position are similar to those about the origins of these projections. However, the pseudo-origin character appears slight or non-existent in the third (*a*-plane) projection and in the three-dimensional Patterson function. These observations have been explained on the basis of a non-crystallographic twofold (or pseudo-twofold) rotation axis parallel (or nearly parallel) to *a*. Given two independent sources of evidence, the symmetry, or, if the dimer structure is not invariant, at least the pseudo-symmetry, of the insulin dimer seems to be established.

The predominant insulin species in solution near neutral *p*H is the hexamer[1b]. A threefold rotation axis relating three dimer units has been found in rhombohedral zinc insulin crystals, space group *R*3, grown under these *p*H conditions[6]. It appears to us that the dimer as a subunit of the hexamer may well have the point group 2. Indeed, it is quite possible that the hexamer has the point group 32 with each single molecule equivalent. (If the hexamer has the point group 32, then the three twofold rotation axes relating the molecules to each other in the dimer subunits lie in a plane normal to the threefold axis and at angles of 120° to each other.) If non-crystallographic twofold axes should exist in the rhombohedral zinc insulin crystal form, they should be detectable, with greater or lesser ease dependent upon their orientation to the threefold axis, by analysis of the vector structure.

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BIOCHEMISTRY

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In 1956[1] a long-chain isoprenoid alcohol, solanesol, was isolated from tobacco and tobacco leaves. While searching for solanesol in animal tissues we have isolated an isoprenoid alcohol of greater chain-length for which we propose the name 'dolichol'.

The characterization of ubichromenol from 46·5 kgm. of human kidney has been described[2,3]. Two fractions weighing 6·41 gm. were eluted between ubiquinone and ubichromenol on chromatography. The infra-red spectrum of the bulked material strongly resembled that of an isoprenoid alcohol[4]. Dolichol was purified from these fractions by forming the acetate, which was then chromatographed, crystallized from ethanol–petrol, and finally saponified to regenerate the alcohol. The alcohol was then crystallized from ethanol–petrol. Both the alcohol and the acetate were colourless viscous liquids at room temperature and white crystalline compounds at low temperature.

Dolichol showed no specific absorption in the ultra-violet region and its infra-red spectrum (all infra-red spectra were examined as films) was very similar to that of solanesol.

$$H(CH_2—\underset{\displaystyle CH_3}{\overset{|}{C}}=CH—CH_2)_9OH$$

Both showed bands indicating a hydroxyl, unconjugated double bonds and the *trans* configuration of those double bonds. The infra-red spectrum of solanesol, however, showed a band at 10μ due to the presence of the allylic alcohol grouping. Dolichol, on the other hand, showed C—O stretching absorption at 9·4μ. Hydrogenation of solanesol and dolichol gave their perhydro-derivatives, and the infra-red spectra of these materials were identical apart from differences in relative intensities consistent with a difference in chain-length. In particular, both saturated materials showed hydroxyl deformations due to the C—O stretching absorption at 9·4μ, and it would seem likely that dolichol contains a primary alcohol grouping but with no αβ-unsaturation.

The analysis of dolichol (C: 86·07; H: 12·18; C—CH_2: 16·64 per cent) fitted a very long chain isoprenoid monohydric alcohol. A molecular weight determination by depression of the freezing point of *cyclo*hexane gave a value of 1,200.

The *p*-phenylazobenzoyl and *p*-nitrobenzoyl esters of dolichol were formed by refluxing with the acid chloride in pyridine. The esters were purified by chromatography on alumina, and the *p*-phenylazobenzoate could be crystallized from ethanol–petrol at low temperature. The ultra-violet absorption spectra of these esters were examined and were compared with the esters formed from other alcohols (Table 1).

Table 1. ULTRA-VIOLET ABSORPTION (IN *cyclo*HEXANE)

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	E(1%, 1 cm.) 324 mμ	Molecular weight of ester	ε 324 mμ
Dolichyl	171·3	—	—
Farnesyl	616·6	430·6	26,550
Cholesteryl	438·0	594·9	26,060
Solanesyl	330·0	839·3	27,700
	p-Nitrobenzoates ($\lambda_{max.}$ at 256 mμ)		
	E(1%, 1 cm.) 256 mμ	Molecular weight of ester	ε 256 mμ
Dolichyl	95·0	—	—
Farnesyl	379·5	371·5	14,090
Phytyl	303·5	445·6	13,520

The mean molecular extinction value (ε) for the *p*-phenylazobenzoates was 26,770 and from this and the E(1%, 1 cm.) of dolichyl *p*-phenylbenzoate the molecular weight of the ester was calculated as 1,563. The molecular weight of dolichol was therefore 1,354. Similarly the mean molecular extinction coefficient for the *p*-nitrobenzoates was 13,800 and hence the molecular weights of the ester and dolichol were 1,453 and 1,300 respectively. A terpenoid alcohol with 19 isoprene residues, $C_{95}H_{153}OH$, has a molecular weight of 1,312 while one with 20 isoprene units, $C_{100}H_{161}OH$, has a molecular weight of 1,380.

The degree of unsaturation of dolichol and dolichyl acetate was examined by determining their iodine values (Dam's method) and by quantitative catalytic hydrogenation (for method see ref. 3). Table 2 shows that the results are in accord with dolichol being a long-chain isoprenoid alcohol.

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$C_{95}H_{153}OH$	(19)	1·448*	367·5*
$C_{100}H_{161}OH$	(20)	1·449*	367·9*
Dolichyl acetate		1·424	369·4
$C_{95}H_{153}O.COCH_3$	(19)	1·404*	356·2*
$C_{100}H_{161}O.COCH_3$	(20)	1·406*	357·0*

* Calculated.

Allylic alcohols will react readily with manganese dioxide[5] to produce αβ-unsaturated aldehydes but saturated alcohols are oxidized by manganese dioxide only with difficulty[6]. Farnesol was refluxed with excess manganese dioxide in petroleum ether (40–60°) for 1 hr. and gave a good yield of farnesaldehyde. Refluxing dolichol and manganese dioxide for 2 hr. in petroleum ether gave a smaller yield of a product which could be crystallized from ethanol–petrol after chromatography on alumina. The product showed only feeble ultra-violet absorption in *cyclo*hexane. The infra-red spectrum of the product showed no hydroxyl band but absorption at 5·75μ characteristic of a saturated aldehyde. Farnesaldehyde showed a band at 5·97μ characteristic of an αβ-unsaturated aldehyde with another band at 6·21μ due to the double bond conjugated to the carbonyl. It seems quite probable that the product from oxidation of dolichol was the expected aldehyde, dolichaldehyde.

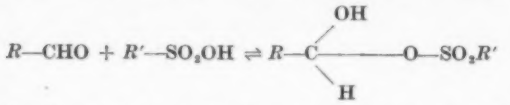
Treatment of dolichaldehyde and farnesaldehyde with a saturated solution of 2 : 4-dinitrophenylhydrazine in 1 per cent ethanolic hydrochloric acid gave the corresponding derivatives, which were purified by chromatography on alumina and crystallization at low temperature. The farnesaldehyde derivative showed in ethanol $\lambda_{max.}$ 382–385 mμ, ε = 29,760, while dolichaldehyde 2 : 4-dinitrophenylhydrazone showed $\lambda_{max.}$ 360 mμ E(1%, 1 cm.) 156·1 (for a molecular weight of 1,312 the molecular extinction coefficient is 20,480). Derivatives of 2 : 4-dinitrophenylhydrazine with no αβ-double bond normally give rise to maximal absorption near 360 mμ with molecular extinction coefficients of 20,000–23,000[7]. A double bond in conjugation with the dinitrophenylhydrazine chromophore causes a bathochromic shift with an increased intensity as shown by the farnesaldehyde derivative.

Ozonolysis of dolichyl acetate yielded acetone and lævulinaldehyde, which were characterized as their 2 : 4-dinitrophenylhydrazones.

It is apparent that the molecule contains 19 or 20 isoprene residues* with a primary alcoholic group. This alcohol grouping has no αβ-unsaturation as in solanesol and the double bond may have been displaced to give βγ-unsaturation or a vinyl grouping. Dolichol has also been isolated from ox kidney, pig kidney, pig heart, pig liver, rat liver and ox intestine.

**Note added in proof.* Specially purified dolichyl acetate has molecular weight 1,422 (20 isoprene residues). We are indebted to Messrs. Hoffmann

which afforded α-cyanobenzyl benzene sulphonate[2], this addition compound could be formed thus:



Another factor influencing the absorption of the aldehydes could be van der Waals adsorption forces, since it is known that compounds containing aromatic residues are adsorbed on polystyrene ion-exchange resins[3–5]. 'Amberlite *IR* 120 (H^+)', which is equivalent to 'Zeo-Karb' 225 [H^+]', has been used[6] to separate phenol, *p*-cresol and 4-tert. butyl phenol. Gabrielson and Samuelson[7] have investigated the adsorption of aldehydes and ketones on 'Amberlite *IRA*–400' (bicarbonate form), which is an anion exchanger of the strongly basic type. They reported that salicylaldehyde and vanillin were strongly absorbed, whereas formaldehyde, acetaldehyde and 2-furaldehyde were eluted almost quantitatively. In this case absorption was attributed to the acidic character of the two aromatic aldehydes.

The unexpected property of derivatives of 2-furaldehyde may prove useful not only in the identification of intermediates in the browning reaction but also those products of acidic degradation of sugars which form the basis of so many colour reactions for the quantitative determination of sugars.

One of us (K. M.) thanks Glaxo, Ltd., for the award of a scholarship.

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Fractionation of Heparin on an Anion Exchanger

Preparations of heparin have been shown to be heterogeneous by a variety of techniques[1,2], but no method is available for the fractionation of bulk quantities of heparin or of other sulphomucopolysaccharides. These compounds carry a strong negative charge over a wide range of *p*H, and, therefore, it seemed possible that they could be purified on basic resins. Five anion-exchange resins ('Dowex–1', 'Dowex–2', 'Dowex–3', 'Amberlite *CG*–45', and 'Duolite *A*–4'), each buffered at *p*H 6·0, readily adsorbed heparin, which was easily eluted with strong salt solutions, but the eluates differed from the original material in having greater absorption at 400 mμ than at 535 mμ in the carbazole reaction[3]. However, 'Ecteola'[4,5] (exchange capacity = 0·3 m.equiv./gm.) resolved a commercial preparation of bovine heparin (obtained from Nutritional Biochemicals Corp.) into four major and one minor carbazole-positive fractions (Fig. 1), each with maximum absorption at 535 mμ, and all showing metachromasia[6]. 90 per cent of the original material was recovered. Heparin-$^{35}SO_4$, extracted from a mast-cell tumour of the mouse[7], gave only one peak on chromatography on 'Ecteola' (Fig. 2), and only 50 per cent of the material was eluted.

Independently, Mozen (personal communication) has used 'Ecteola' for the resolution of heparin and found that those fractions that came off the column

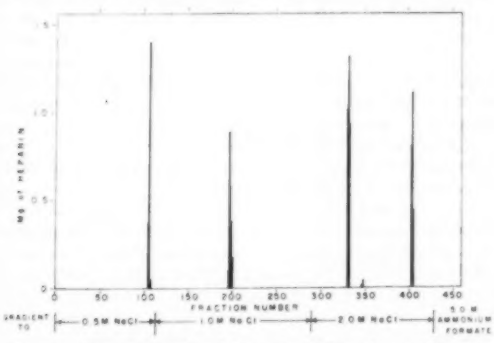

Fig. 1. Chromatography of 10 mgm. of heparin on 'Ecteola' (10 gm.; 2 × 9 cm.; flow-rate 4·0 ml./hr.). The heparin was applied in 100 ml. water. A gradient elution system was used, with a single mixing chamber containing 400 ml. water. Each fraction contained 5·5 ml.

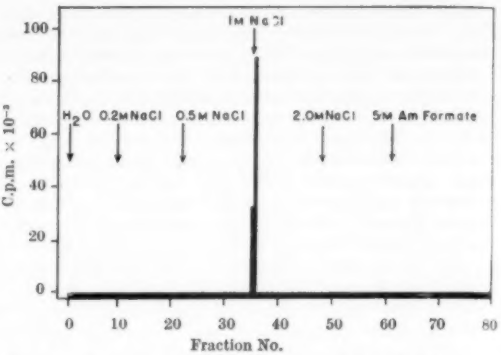

Fig. 2. Chromatography of mouse mast-cell heparin-$^{35}SO_4$ on 'Ecteola'. Each fraction contained 10 ml.

latest had the highest anti-coagulant potency, as well as the highest sulphate content.

This work was supported by the American Heart Association and the Life Insurance Medical Research Fund. I am indebted to Dr. Margaret Day for providing the mast-cell tumour and to Miss Bella Wu and Mr. Mark Lavietes for technical assistance.

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Mammalian α-L-Fucosidase

According to our surmise that the enzymes, β-N-acetylglucosaminidase, α-mannosidase and β-galactosidase, with their particularly high activity in the epididymis[1,2], are concerned in the breakdown of mucosubstances, they should be accompanied by an L-fucosidase. Serological evidence suggests that the L-fucose (6-deoxy-L-galactose) residue present in many mucopolysaccharides has the α-configuration[3,4]. Rat epididymis has now been found to have an α-L-fucosidase activity of about 20,000 units per gm. moist weight, compared with activities of about 4,000 units per gm. in organs such as liver, where 1 unit of enzyme liberates 1 μgm. *p*-nitrophenol in 1 hr. at 37° from *p*-nitrophenyl α-L-fucoside in an arbitrary concentration of 1 m*M*. The maximum activity is displayed at about *p*H 6. There is no α-D-fucosidase activity in mammalian tissues, but the limpet, *Patella vulgata*, with a high α-L-fucosidase activity, has a feeble effect on the related α-D-fucoside. This may well be a side-action of α-D-galactosidase.

Whereas β-glycosidases are always inhibited by the aldonolactones of corresponding configuration, the α-glycosidases only sometimes display this pheno-

menon[5,6]. It was shown that the hydrolysis of either of the α-fucosides was not depressed by the appropriate fuconolactone. Attempts to prepare suitable β-fucosides for enzyme work have thus far been unsuccessful.

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Supercontraction of Wool Fibres and Creep in the Post-yield Region

IT is now well established that hydrogen bonding takes a major role in the stabilization of wool keratin. This is well demonstrated by the recent finding[1] that wool fibres supercontract by 70 per cent of their length in 1 *N* hydrochloric acid containing 4 *M* concentrations of sodium iodide. In agreement with earlier workers[2], it was considered that the process took place in two phases corresponding to areas of strong and weak hydrogen bonding lying in series along the microfibrils.

I have been applying this technique to wool samples exhibiting marked variations in their post-yield creep properties and have noted two significant features.

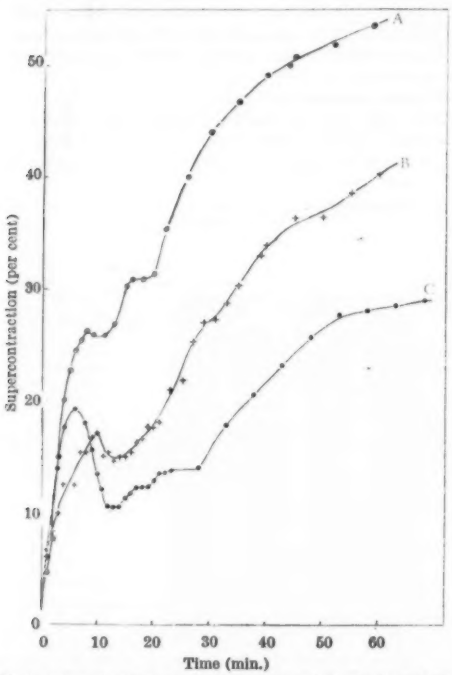

Fig. 1. Typical kinetic contraction curves of single fibres drawn from samples *A*, *B* and *C* at 98·5° C. in 1 *N* hydrochloric acid containing 4 *M* concentrations of sodium iodide

First, as has already been observed, there are large variations between samples (Fig. 1) and between fibres drawn from the same sample. Secondly, the later stages of the 1 hr. supercontraction bear a relation to the post-yield creep of the fibres (Table 1).

Table 1

Sample	Creep constant (arbitrary units)
A	53·6
B	21·9
C	13·5

It appears, therefore, that the 'strong' hydrogen bonds responsible for the later phases of supercontraction may also account for a major part of the technologically significant variations in the creep properties of wool fibres[3].

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PHYSIOLOGY

Absence of Catecholamines in Cardioactive Acetone Extracts of Ox Spleen

IT has been shown that acetone extracts of freeze-dried ox spleen are capable of stimulating hypodynamic papillary muscle[1]. Evidence has been reported recently[2] which suggests that the cardioactivity cannot be explained in terms of choline or its esters, histamine, 5-hydroxytryptamine, adrenaline or noradrenaline. Further experiments reported below confirm the absence of catecholamines in an active extract.

The amplitude of cardiac contractions was recorded by a Cushny myocardiograph sutured to the right ventricles of artificially respired guinea pigs anæsthetized with pentobarbitone sodium (45 mgm./kgm. intraperitoneally). The animals were pretreated with atropine sulphate (2 mgm./kgm. subcutaneously), promethazine hydrochloride (5 mgm. intramuscularly) and ergotamine tartrate ('Gynergen') 0·15 mgm./kgm. intramuscularly. A small moistened cotton-wool cover was arranged to prevent drying of the thoracic tissues without interfering with the movements of the heart, lungs or myocardiograph. Injections of drugs were made into the right jugular vein in small volumes, approximately 0·1 ml., and washed into the circulation with 0·2 ml. normal saline.

Injection of 1–2 μgm. noradrenaline caused transient positive inotropic actions which were approximately matched by 10–25 mgm. doses of spleen extract (corresponding to quantities of fresh spleen between 6·7 and 17·2 gm.). Following doses of dichloro*iso*prenaline, a specific antagonist to the inotropic and chronotropic actions of the catecholamines[3], the effects of noradrenaline were almost completely abolished, whereas the inotropic effect of the spleen extract was not significantly altered (Fig. 1).

Further evidence that the inotropic principle in extracts of spleen differed from the catecholamines was obtained from paper chromatographic tests using Vogt's[4] modification of the technique described by Crawford and Outschoorn[5] using an atmosphere

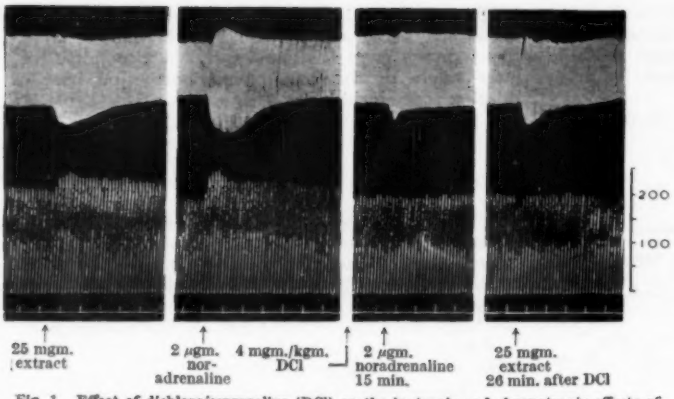

Fig. 1. Effect of dichloro*iso*prenaline (DCl) on the inotropic and chronotropic effects of noradrenaline and spleen extract in the intact anæsthetized guinea pig

of carbon dioxide in the tank. Samples of spleen extract sufficient to cause inotropic effects on papillary muscles in a 20-ml. bath were applied to Whatman No. 1 paper from a concentrated solution. Adrenaline, noradrenaline and dopamine (3-hydroxy-tyramine) were applied in 10-μgm. quantities to the paper. After development and removal of solvents, the chromatogram was sprayed with the ferricyanide reagent of James[6]. The catecholamines showed up clearly and good separation was achieved from a mixture. No colour reaction was observed with the samples of spleen extract, indicating that catecholamines were not present in significant quantities.

This evidence, together with that previously reported[2], seems to point conclusively to the absence of catecholamines in acetone extracts of freeze-dried spleen and suggests that the inotropic activity of these extracts is due to some other factors.

We are indebted to Dr. C. E. Powell for a generous gift of dichloro*iso*prenaline.

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Active Transport of γ-Aminobutyric Acid in Brain Cortex Slices, with Special Reference to Phosphorus-32 Turnover of Phospholipids in Cytoplasmic Particulates

When slices of guinea pig brain cortex were incubated aerobically at 37° C. in a saline medium containing amino-acid such as γ-aminobutyric acid or glutamate, the amino-acid was accumulated in the brain slices actively from the medium against its concentration gradient in the presence of glucose as a substrate. Terner *et al.*[1] reported that L-glutamate accumulated in brain slices accompanied by potassium ions when they were incubated aerobically in the medium containing glucose. Also as reported previously[2], non-metabolizable D-isomer of glutamic acid accumulated in the brain slices in the same manner.

If γ-aminobutyric acid, a neutral amino-acid, which has an important effect on nervous functions, was present in the medium in the concentration of 5 m*M* instead of glutamate, it also accumulated actively in the brain slices depending upon energy-yielding processes (Table 1). In this case, however, there was very little change in the intracellular potassium and water content on a dry-weight basis calculated by chloride assumption. The active transport of γ-aminobutyric acid in the slices was observed only with brain tissue, not with liver or kidney. In calcium-free medium, γ-aminobutyric acid was more actively transported in the slices; on the other hand, on omitting potassium ions from the medium, γ-aminobutyric acid transport was markedly suppressed (Table 1). By the addition of pyridoxal in the concentration of 1 m*M*, the accumulation of γ-aminobutyric acid was also augmented remarkably just as in the case of glycine uptake by carcinoma cells as described by Christensen *et al.*[3].

Slice/medium ratio indicated in Table 1 was indicative of amino-acid transport in the slices. If this value represents more than 1·0, γ-aminobutyric acid should accumulate actively from the medium against its concentration gradient, since the intrinsic concentration of the acid in the nerve cell might be considered to be about 5 m*M*/kgm. as in the medium. Under these conditions, only γ-aminobutyric acid is transported across the cell membrane as a neutral substance without any considerable movements of extra cations.

We were interested in the carrier system of γ-aminobutyric acid transportation across the nerve cell membrane against the concentration gradient in relation to phosphorus-32 turnover of phospholipid

Table 1. Accumulation of Amino-Acid into Guinea Pig Brain Cortex Slices

Conditions	Amino-acid slice/medium ratio	(Cl-space) Intracellular water (ml./gm. dry weight) Mean ± S.D.	Intracellular K^+ (m.equiv./gm. dry weight) Mean ± S.D.
No substrate	None	1·65 ± 0·12 (4)	0·203 ± 0·05 (4)
Glucose–Ringer		1·85 ± 0·20 (11)	0·368 ± 0·01 (11)
With γ-amino-butyric acid (5 m*M*)			
No substrate	2·30 (3)	1·75 ± 0·24 (5)	0·194 ± 0·048 (5)
Glucose–Ringer	3·60 (4)	2·06 ± 0·56 (4)	0·330 ± 0·022 (4)
+ Calcium-free	4·06 (5)	2·22 ± 0·10 (3)	0·320 ± 0·014 (3)
+ Potassium-free	1·89 (4)	1·56 ± 0·42 (3)	0·177 ± 0·038 (3)
+ Pyridoxal (1 m*M*)	4·96 (2)		
+ 2,4-Dinitro-phenol (5×10^{-4} *M*	2·59 (2)		

Slices were incubated in Krebs–Ringer phosphate (sodium, 140 m.equiv./l.; potassium, 7·26 m.equiv./l.; calcium, 2·75 m.equiv./l.; magnesium, 2·62 m.equiv./l.; chloride, 139 m.equiv./l.; phosphorus, 10·8 m*M*/l.) with 5 m*M* γ-aminobutyric acid. Amino-acids were measured paper chromatographically by ninhydrin colour development. Sodium and potassium were estimated by flame photometry and chloride by Lowry's method (ref. 7) after the extraction of dried tissue by 0·1 *N* nitric acid.

Table 2. PHOSPHORUS-32 INCORPORATION INTO PHOSPHOLIPID FRACTIONS OF CYTOPLASMIC PARTICULATES OF GUINEA PIG BRAIN

	Specific activity	Increase (per cent)	Total counts (c.p.m./gm. tissue) Phosphatidic acid	Phosphatidyl-choline	Monophospho-inositide
Control	118	100	6,050	379	2,070
+γ-Amino-butyric acid (5 m*M*)	154	131	8,880	520	1,170
+Calcium-free +γ-amino-butyric acid	190	161	11,200	1,190	2,350
+Potassum-free + γ-amino-butyric acid	116	98	5,930	509	1,620
+Pyridoxal (1 m*M*) + γ-amino-butyric acid	189	160	15,900	882	1,420
Potassium-rich (sodium, 90 m*M*; potassium, 50 m*M*)	312	264	14,300	2,610	2,740

Slices were incubated in 2-ml. medium containing equal radioactivity of phosphorus-32. Specific activity was expressed as the value of the counts per min. per phospholipid phosphorus. The total counts of each phospholipid represented as counts per min. per gm. wet weight tissue.

fractions in brain tissue, which are present in fairly high concentration in the membrane structure. Guinea pig brain cortex slices (300–400 mgm.) were incubated for 60 min. in the medium containing 5 m*M* γ-aminobutyric acid and phosphorus-32 as a tracer. After the incubation period, slices were homogenized in 0·25 *M* sucrose in the cold. The cytoplasmic particulate fraction was obtained by centrifugation at 40,000 r.p.m. (105,000*g*) for 15 min. in the cold after the removal of cell debris; then the particulates were washed once, resuspended in 0·25 *M* sucrose and centrifuged again. Ethanol/ether (1 : 1) soluble lipids were extracted in the acidic state at 4° C. overnight from the cytoplasmic particulates fraction. The phospholipids extracted were separated by chromatography on silicic acid-impregnated paper with di*iso*butylketone/acetic acid/water in the proportions of 40 : 30 : 7 as described by Hokin *et al.*[4]. A contact radioautogram was taken with X-ray film. The identification of spots on the radioautogram was made by reference to the mild alkaline hydrolysis method of Dawson[5] rather than Hokin's procedure.

The incorporation of phosphorus-32 into the phospholipids, particularly phosphatidic acid and phosphatidyl choline, in the washed cytoplasmic particulate fraction was clearly increased accompanied by the accumulation of γ-aminobutyric acid in the slices. Moreover, on the addition of calcium-free medium or of pyridoxal (1 m*M*), phosphorus-32 incorporation was accelerated. On the contrary, when γ-aminobutyric acid did not accumulate in the slices on the condition of potassium-free medium, incorporation of phosphorus-32 in the phospholipids was diminished as shown in Table 2 and Fig. 1.

As reported previously[6], potassium-rich medium containing sodium ions (potassium : 50 m.equiv./l., sodium : 90 m.equiv./l.) stimulated the metabolism of brain slices such as oxygen uptake, glycolysis and incorporation of phosphorus-32 into phosphoprotein fractions. In these circumstances, the incorporation of phosphorus-32 into phospholipids of brain cytoplasmic particulates was also strongly stimulated. This suggests that some relationship exists between active transport of cations such as potassium influx and sodium efflux across the cell membrane and phosphorus-32 turnover of phospholipids.

From these results, phospholipids in cytoplasmic particulates of brain tissue, which are thought to be a main structure of the cell membrane electronmicroscopically, would play an important part as carriers in the active transport of amino-acid or cations across the nerve cell membrane.

Details will be published elsewhere later.

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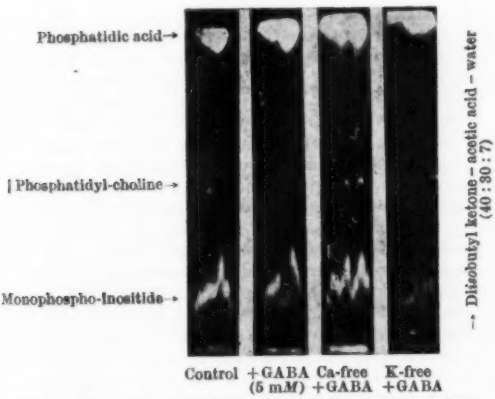

Fig. 1. Phosphorus-32 radioautogram of phospholipid in brain particulates

Histophotometrical Study of the Effect of Interstitial Cell-stimulating Hormone on the Deoxyribonucleic Acid Content of the Testicular Interstitial Cell Nucleus in the Adult Rat

IN our investigations of the relation between cell activity and deoxyribonucleic acid content of the nucleus in endocrine glands, we had the opportunity to study the influence of stimulation of the testicular interstitial cells by means of interstitial cell-stimulating hormone on the mean deoxyribonucleic acid content of their nuclei.

Ten male adult rats, 7–8 months old, were used. While 5 of these were controls, to each of the other rats 50 I.U. of interstitial cell-stimulating hormone have been given intramuscularly per 24 hr., for 14 successive days. All animals were beheaded simultaneously. The testes were fixed in alcohol/

Table 1

	Deoxyribonucleic acid content of interstitial cell nuclei					
	No.	$\bar{x}$	$\log \bar{x}$	n	s	$s_{\log \bar{x}}$
Controls	338	1,111	3·0458	50	0·0630	0·00893
	339	1,088	2·0367	50	0·0570	0·00742
	340	1,053	3·0223	50	0·0492	0·00695
	341	1,096	3·0397	50	0·0490	0·00692
	342	1,178	3·0710	50	0·0475	0·00673
	Average	1,102	3·0424	250	0·0550	0·00356
Treated with interstitial cell-stimulating hormone	353	1,199	3·0789	50	0·0599	0·00849
	354	1,203	3·0801	50	0·0536	0·00642
	355	1,193	3·0766	50	0·0454	0·00642
	356	1,213	3·0837	50	0·0487	0·00688
	357	1,178	3·0710	50	0·0506	0·00716
	Average	1,198	3·0784	250	0·0561	0·00348

formalin/acetic acid (75 : 20 : 5) and cut at 10μ. Sections were prepared on the same slide in order to submit them to the Feulgen reaction under identical conditions. The deoxyribonucleic acid content was measured in individual nuclei by the histophotometrical method of L. Lison[1] and expressed in arbitrary units.

Table 1 summarizes the results; since the individual nuclear contents vary following a log-normal distribution, the log $\bar{x}$ values were used for statistical computations.

When comparing the pooled results of the two groups, it is seen that after treatment with interstitial cell-stimulating hormone there is an 8·7 per cent increase in the mean deoxyribonucleic acid content of the nuclei of the interstitial cells (t = 7,651; $P \ll 0{\cdot}001$). These results demonstrate once more a stimulation of cell activity accompanied by increase of the mean deoxyribonucleic acid content of the nuclei.

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Spontaneous Potential Changes at Crayfish Neuromuscular Junctions

An important feature of vertebrate neuromuscular transmission is that acetylcholine is released from the nerve terminals in 'packets'. At rest, a spontaneous discharge of these packets gives rise to 'miniature end-plate potentials'[1]. We were therefore interested whether this mechanism of transmitter release also occurs at a non-cholinergic crustacean neuromuscular junction.

In the abductor of the dactylopodite of the first walking leg of the crayfish (*Orconectes virilis*), spontaneous potentials of up to 0·8 mV. were recorded with intracellular electrodes (20–25° C., pH 7·2). The time course of these potentials (Fig. 1*A*) was similar to that of an excitatory junctional potential set up by stimulation of the motor axon. The largest spontaneous potentials were found in those fibres with the smallest diameters (about 100μ) and a relatively high input resistance (about 0·5 MΩ). They could be recorded from any point in the muscle fibre, in the same manner as excitatory junctional potentials[2]. The amplitude of consecutive spontaneous potentials varied considerably (Fig. 1*B*). Smaller potentials seemed to have a longer rise time (Fig. 1*A*),

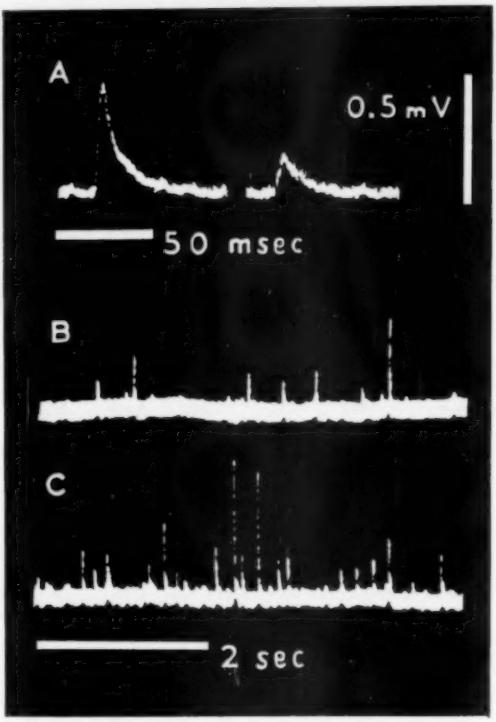

Fig. 1. Spontaneous potentials from a crayfish muscle fibre with intracellular recording, resting potential 78 mV. *A* and *B* in normal van Harreveld solution. *C*, molarity of van Harreveld solution increased by addition of 125 m*M* sucrose. Voltage calibration same for *A*, *B* and *C*; 50 msec. calibration for *A*, 2 sec. for *B* and *C*

suggesting that they arose at a greater distance from the recording electrode. Frequencies in different fibres were between 0·1 and 10 per second. The potentials appeared to occur at random intervals. Statistical tests[3] confirmed that there was no noticeable interaction between single events. Our findings are similar to those of Burke[4], who recorded 'miniature end-plate potentials' in the frog's slow muscle fibres which also have motor nerve endings distributed over the entire fibre surface.

At vertebrate neuromuscular junctions the frequency of 'miniature end-plate potentials' is increased when the osmolarity of the extracellular fluid is raised[3]. This also applies to crustacean neuromuscular junctions. Thus in Fig. 1*C* a 50 per cent increase in osmolarity raised the frequency three times over that in Fig. 1*B*. Doubling the osmotic pressure resulted in a seven-fold rise in frequency. It seems unlikely that the spontaneous potentials arise from spontaneous conducted impulses in branches of the motor axon. Thus a five-fold increase in calcium concentration (to 67 m*M*/l., replacing sodium) prevented the appearance of an excitatory junctional potential following stimulation of the motor axon, but did not appreciably affect the spontaneous discharge. We could further exclude the release of inhibitory transmitter as the cause of spontaneous activity. When the membrane potential was shifted by passing current across the membrane the inhibitory junctional potential reversed its sign at the chloride equilibrium

potential as previously seen by others[5]. The spontaneous activity, however, was not affected.

If the spontaneous potentials arise from transmitter released from excitatory nerve endings, one might expect the frequency of the discharge to be altered following stimulation of the excitatory nerve[6]. Fig. 2 shows that during the first second following a burst of excitatory junctional potentials at 100 per sec. for 1 sec. the frequency of the spontaneous potentials was increased; afterwards, however, the frequency was markedly decreased for a considerable period. If the duration of the excitatory stimulation was lengthened from 1 to 10 sec., only the decrease in frequency was observed for the entire 30-sec. interval between bursts of stimulations.

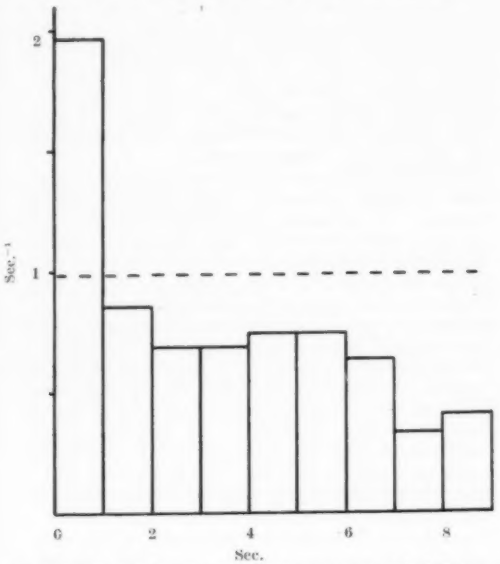

Fig. 2. Change in frequency of spontaneous potentials following stimulation of the motor axon. Abscissa: time after end of stimulation of excitatory axon at 100/sec. for 1 sec., every 10 sec. Ordinate: number of spontaneous potentials observed per sec., average of 27 consecutive intervals between stimulations. The dotted line indicates the average frequency of spontaneous potentials at rest

All the observations are consistent with the assumption that the spontaneous potentials are analogous to 'miniature end-plate potentials' of vertebrates. However, until the chemical identity of the excitatory transmitter in these muscle fibres is known, more direct evidence that these potentials arise from the spontaneous release of transmitter from the nerve terminal will be difficult to obtain.

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Spontaneous Potentials from Explants of Brain Tissue in Culture

SINCE July 1959 we have been recording spontaneous potentials from explants of brain in tissue culture. The tissue used was cerebellum from chick embryos of 8 days incubation and older. The supernatant was a 0·25 per cent solution of human serum protein in a physiologically balanced salt solution. The composition of the physiological balanced salt solution is as follows:

Potassium chloride	0·28 gm./litre
Sodium chloride	7·0 ,,
Calcium chloride	0·28 ,,
Magnesium sulphate	0·15 ,,
Di-sodium hydrogen phosphate	0·08 ,,
Di-potassium hydrogen phosphate	0·04 ,,
Sodium bicarbonate	1·05 ,,
Sodium acetate	0·05 ,,
Dextrose	1·75 ,,

The other techniques were those described in publications from this laboratory[1–3].

Spontaneous potentials have been obtained from cultures both in Kahn tubes and in flow systems as bursts of activity and as sustained activity from the time of explantation until another 14 days in culture. We have used a d.c. amplifier of our own design and a Dumont oscilloscope or Texas Instrument's 'Rectiriter'. The actual disturbance is illustrated in Fig. 1 and is composed of step-like combinations of positive and negative potentials lasting from a half to one and a half seconds each with a magnitude of up to 25 μV. Each culture had a simultaneous electrically inert control (dead brain tissue, pure epithelium cartilage or cornea without iris) with a repeated exchange of recording channel between control and brain tissue to exclude artefacts. We have been un-

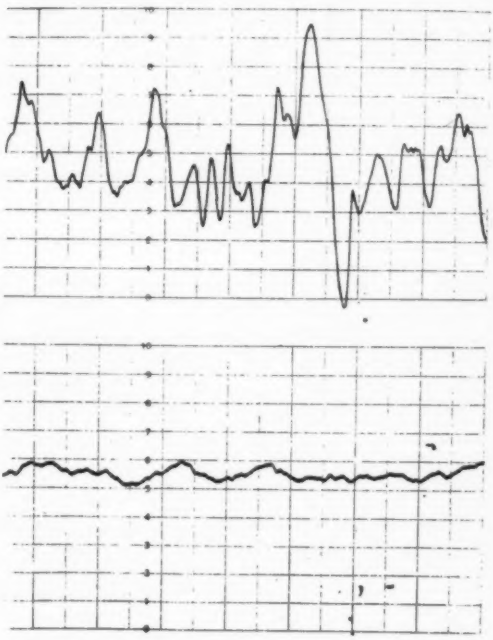

Fig. 1. Simultaneous dual-channel recording of spontaneous electrical activity from explants of chick embryo cerebellum in culture (upper channel) and control of dead brain tissue (lower channel). Full-scale vertical deflexion equals 25 μV. Time interval between each major horizontal division is 2·5 sec.

able to find any other record of spontaneous potentials from explants of brain tissue in culture.

Further investigations on these potentials are in progress.

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Activity of Muscle Receptors in the Kitten

In recent experiments[1] it was found that the tonic stretch reflex is lacking in the distal muscles of the limbs of the newly born kitten. Evidence was also presented that the gradual appearance of this reflex is due to a postnatal development of its afferent link, because its efferent link can easily be activated from other sources than stretch receptors at birth. The postnatal development of the afferent link is partly a maturation of the central connexions and functions of the muscle afferents[2–4], but as will be reported here it also consists of a development of the stretch receptors.

Whether or not the muscle spindles are functioning properly in the muscles lacking tonic stretch reflexes was, of course, one of the first questions asked. The study of these receptors in a newly born animal, however, met with great technical difficulties. Out of these has only to be mentioned that the fibre diameter of the largest afferents from, for example, the gastrocnemius muscle is about 2μ, making the isolation and recording from single functioning receptors extremely difficult. Recordings from a great many receptors have, however, been obtained by now allowing an evaluation of the experimental results.

The discharge of the stretch receptors in the gastrocnemius muscle has been studied both in dissected fibres of the dorsal roots *L* 7 and *S* 1 and in the muscle nerve. The ventral roots *L* 7 and *S* 1 were stimulated with square-wave shocks of 0·5 msec. duration given either singly or in a short tetanus. Muscle tension was recorded isometrically. The temperatures of the whole animal and of the muscle used were continuously controlled.

Recordings from the dorsal root of the muscle nerve of the discharge of the stretch receptors in the gastrocnemius muscle have shown that a sustained discharge in response to stretch is usually lacking in the newly born animal. When later present the frequency of the response is very low (Fig. 1*A* and Fig. 2) and soon adapts to zero. Repeated stretching of the muscle, however, gives rise to a response every time, as shown in Fig. 1*B*, even in the newly born animal. The lack of a sustained discharge makes a differentiation by behaviour during contraction between the responding receptors difficult. Intra-arterial injection of subparalytic doses of succinylcholine iodide, which is known to activate the muscle spindles selectively[5], sometimes makes the spindles fire continuously in the newly born animal, but always sensitizes them to respond with a few spikes on the falling phase of the contraction. By the use of this drug it was possible to differentiate between the responding receptors. It has thus been found that both muscle spindles and tendon organs in the gastrocnemius muscle of a newly born animal can be activated by stretch, but usually only phasically. It has constantly been found, however, that sustained discharges are obtained from proximally lying muscles around the hip and spine which usually are difficult to get rid of by denervation. In listening to the discharge of these receptors in the loudspeaker on stimulation of the ventral roots it can be heard that both spindles and tendon organs are present among the continuously firing receptors.

The muscles in the newly born kitten are known to have different properties from those in the adult animal[6]. It has here been found that they, besides having a slow contraction, are extremely plastic (see Fig. 2). The intrafusal fibres of the muscle spindles are known to grow out from extrafusal ones[7], and the plasticity could thus offer one explanation for the fast adaptation and inability of the muscle spindles to set up sustained discharges in response to stretch. If this was the only explanation, continually re-adjusting the tension to high values would set up sustained discharges. That has, however, not been found to be the case. The observation by Hursh[8], repeatedly confirmed during this investigation, that the absolute refractory period is twice as long as in the adult nerve before the developing fibres reach a conduction velocity of 18–20 m./sec., points to properties of the nerve fibres in the newly born animal that might prevent repetitive firing, at least with high frequencies.

Fig. 1. The response of stretch receptors in the gastrocnemius muscle of a 3-day-old kitten recorded in a small twig of the medial nerve to the muscle during 8-mm. stretch

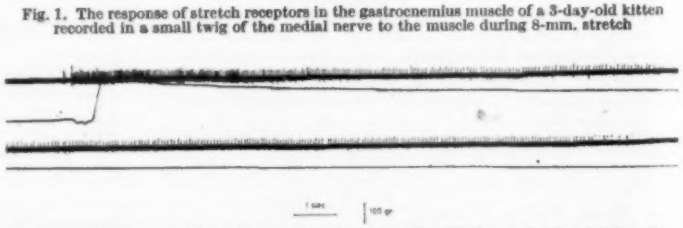

Fig. 2. The response of stretch receptors in the gastrocnemius muscle of a 10-day-old kitten to 12-mm. stretch, recorded in a fine filament of the dorsal root *S* 1. Note the fall in tension due to plasticity in the muscle, which is kept at constant length

A combination of immaturity of the sense organ with regard to mechanical properties and of the afferent fibre with regard to excitability (not necessarily a function of its diameter which is but a good correlative measure) explains the adaptation and the inability to respond to both high tensions and succinylcholine iodide with sustained discharges respectively. In conformity with this, it has been found that the stretch receptors usually fire continuously when the conduction velocity of the afferents has reached 18–20 m./sec., which happens 8–10 days postnatally, but as can be imagined from Fig. 2 adaptation due to plasticity will still play a great part in small extensions.

In trying to find out when the gamma-efferents start activating the muscle spindle, it was found that stimulation slightly above threshold for the alpha-fibres often activated a few spikes during the early phase of a muscle contraction. This is thought to be an alpha-activation of the spindle[3] which appears earlier postnatally than the well-known gamma-excitation, which is obtained 18–20 days postnatally.

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Histochemical Demonstration of Ascorbic Acid in the Locus Coeruleus of the Mammalian Brain

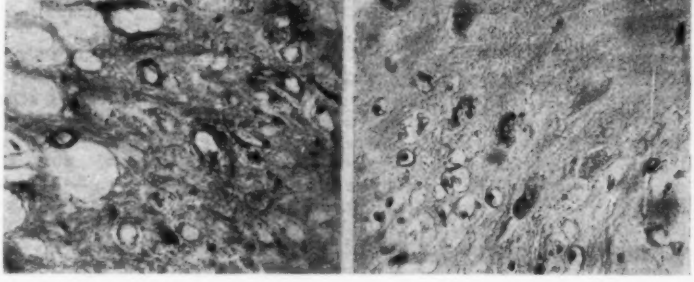
Diehl and Neumann[1] have determined the content of ascorbic acid in the various portions of the human brain and found a characteristically high content in the autonomic centres (tuber cinereum and medulla oblongata). By means of the histochemical method the neurosecretory nuclei of the hypothalamus were reported to contain many silver granules due to reduction of silver nitrate by ascorbic acid[2–4]. Although in the above chemical and histochemical reports particular attention was not paid to the locus coeruleus, the locus was recently found by a histochemical method (Shimizu *et al.*[5,6]) to demonstrate the pronounced activity of monoamine oxidase, and by several physiological investigations[7–9] to regulate respiration, as the pneumotaxic centres. As the locus coeruleus was thus supposed to display some autonomic (visceral) functions, which might be related to amine metabolism, we thought it reasonable to search for the histochemical presence of ascorbic acid in the locus coeruleus.

Experimental animals used consisted of healthy adult mice, rats and guinea pigs and also scorbutic guinea pigs. Thin slices of the brain were fixed in the acidified silver nitrate solution for 30 min. according to Giroud and Leblond's method (cf. Gomori[10], and Lison[11]) following intravascular perfusion first with an isotonic fructose solution and then the silver nitrate solution.

In the brain of the normal animals tested silver granules due to the presence of ascorbic acid occurred most abundantly in mice, intermediately in rats and least of all in guinea pigs. In mice and rats large amounts of silver granules were demonstrated constantly in the locus coeruleus (Fig. 1), where the silver granules were mainly encountered within the nerve cell bodies. The same observation was also made in the paraventricular and supra-optic nuclei of the hypothalamus as other investigators[2–4] already reported. Similar but less evident deposition of silver granules was further revealed in the dorsal nucleus of the vagus nerve and area postrema of mice. Regions of the brain other than the above nuclei showed rather irregular deposition of silver granules, which were present in small (rats) or moderate amounts (mice). For example, varying amounts of silver granules were found in the nerve-cell bodies of the cerebral and cerebellar cortices.

The brains of normal healthy guinea pigs showed the deposition of silver granules much less clearly than those of rats and mice and the silver granules were demonstrable exclusively in limited portions of the brain in contrast to the observation in rats and mice. Moderate amounts of silver granules (Fig. 2) were shown in the nerve cell-bodies of the locus coeruleus as well as in those of the paraventricular nucleus. Small numbers of the granules were present, furthermore, in the supra-optic nucleus, dorsal nucleus of the vagus nerve and area postrema. These silver granules were completely abolished in the scorbutic guinea pigs, which were fed on the vitamin C deficient diet for about twenty days. This observation indicates that the deposition of silver granules in the above nuclei might be due to the presence of ascorbic acid.

Our observations that ascorbic acid is concentrated in the locus coeruleus, dorsal nucleus of the vagus nerve and area postrema as well as in the hypothalamus lead us to suppose that this vitamin might be



Figs. 1 and 2. Distribution of ascorbic acid in the brain, stained by the Giroud and Leblond method. The silver granules are due to a reduction of acidified silver nitrate by ascorbic acid. Fig. 1. Locus coeruleus of rat. A large amount of silver granules is demonstrated mainly within the nerve cells of the locus coeruleus. Several large nerve cells of the mesencephalic nucleus of the trigeminal nerve (at the left hand of the figure) are essentially devoid of silver granules (× *c.* 330). Fig. 2. Locus coeruleus of guinea pig. Moderate amounts of silver granules are encountered in several nerve cells of the locus coeruleus (× *c.* 330)

implicated in the metabolism of the autonomic centres of the brain. Ascorbic acid is said to be required for the oxidation of tyrosine and in this process it does not seem to act as a specific cofactor and its role is probably that of a reducing agent (cf. Mehler[12], Fruton *et al.*[13]). Co-existence of ascorbic acid with monoamine oxidase might constitute a suitable condition for the active aromatic amine metabolism in these nuclei.

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Serotonin Content of the Pineal Glands of Man and Monkey

Giarman *et al.* have demonstrated the presence of certain neurohumours and some of their associated enzymes in the bovine pineal gland[1,2]. While determining the relative distribution of serotonin in specific areas of human brain, we have obtained the pineal glands of deceased mental patients. The glands were removed within 24 hr. *post mortem*, and kept at the temperature of dry ice, usually for 24 hr., when extraction of serotonin was carried out. Only minimal losses are encountered with such a procedure. The pineals were homogenized with 2 ml. of isotonic salt solution and the amine extracted with 95 per cent acetone by a modification of the method of Amin, Crawford and Gaddum[3]. Estimation of the content of serotonin in the extracts was made by assay on the heart of *Venus mercenaria*[4]. For purposes of comparison freshly excised pineal glands from non-psychotic deceased patients and from 17 rhesus monkeys were treated and assayed in the same manner. Table 1 summarizes the results presented here and includes some values obtained previously[2] from freshly excised and fresh-frozen bovine glands.

It is clear that the pineal gland of both man and monkey is considerably richer in serotonin than that of the cow. In fact, the serotonin-levels found in the majority of human and simian glands are the highest ever reported for any neural structure of any species examined. These values approach the levels found in the spleen and portions of the gastro-intestinal tract. Moreover, pretreatment with the monoamine oxidase inhibitor, iproniazid ('Marsilid'), fails to give values in this range either in whole rat's brain[5] or in specific areas of the dog's brain[6]. Our study of other regions of the human brain has shown high values of 0·48 γ/gm. in the central grey of the midbrain and 0·43 γ/gm. in the reticulum of the medulla oblongata

Table 1. Serotonin in Human, Simian and Bovine Pineal Glands

Species	Age	Diagnosis	Weight of pineals (gm.)	Serotonin content (γ/gm.)
Human male	89	Cerebral arterio-sclerosis	0·120	1·00
Human male	76	Manic depressive	1·890	0·36
Human female	78	Chronic schizophrenic	0·450	10·00
Human male	84	Senile brain disease	0·480	5·33
Human male	37	Schizophrenic reaction, chronic	0·305	0·59
Human male	40	Schizophrenic reaction, chronic	0·285	1·54
Human male	90	Chronic brain syndrome	0·115	2·08
Human male	45	Chronic brain syndrome; also delirium tremens	0·210	22·82
Human female	44	Cirrhosis of liver	0·130	5·77
Human male	86	Bronchogenic carcinoma	0·095	2·63
Human male	74	Myocardial infarct.	0·110	2·18
17 Rhesus monkeys (adult male)			Mean Range	3·28 1·20–10·00
13 Steers			Mean Range	0·40 0·20–0·63

(Freedman, D. X., Picard-Ami, L., and Giarman, N. J., unpublished work). Costa and Aprison have reported high values of 0·5–1·0 γ/gm., which they found in mesencephalic and diencephalic structures of the human brain[7].

The greatest variability of serotonin content was found in the human pineal gland, with values ranging from 0·36 γ/gm. to 22·82 γ/gm. (see Table 1). While these human glands (especially those from psychotic patients) showed great variation in weight, there was clearly no correlation between weight and serotonin content. In contrast, the serotonin content of the bovine pineal glands fell within the relatively narrow range of 0·20 γ/gm.–0·63 γ/gm., and their weight was an almost uniform 0·20 gm. The variability in the serotonin content of the simian glands fell between that of the human and that of the bovine glands. It was established in control experiments that the prior ingestion of bananas failed to correlate with elevated serotonin-levels found in the simian pineal glands.

The seemingly greater variability of values in the glands taken from patients with psychiatric disorders than in those from the three representatives of the 'normal' population cannot be interpreted because of the small sample and wide range of diagnoses represented. Any apparent trend requires replication of studies from selected diagnostic categories and investigation, among other factors, of histology and of relative monoamine oxidase activities. One inference we might currently make refers to the apparent unrelatedness of serotonin content of the human pineal to age in the group 35–90 years of age.

Despite a long-standing philosophical and scientific interest in the pineal gland and a large number of somewhat sporadic investigations[8] the function of the pineal and the relation of this function to its chemistry or pathology are still unknown. Similarly, any proposed relationship of the pineal gland and mental function[9] lacks confirmation by other investigators. On the other hand, possible inter-relationships of the pineal with the adrenal cortex, gonads, and the pituitary gland have been reported. Farrell *et al.*[10] noted that destruction of the pineal region reduced secretion of aldosterone by the adrenal cortex, while infusion of bovine pineal extract restored such secretion to normal (Farrell, G., unpublished results sent in personal communication from E. S. Redgate).

Lerner *et al.*[11] have isolated a skin-lightening hormone, melatonin, from the bovine pineal gland, and found it to antagonize the skin-darkening effect of melanocyte-stimulating hormone, secreted by the neurohypophysis. Wurtman *et al.*[12] reported that pinealectomy in young female rats led to pituitary and gonadal hypertrophy, which was reversible by injection of pineal extract. These findings and our earlier reports[1,2] on the presence of neurohumours and associated enzymes in the bovine pineal gland tend to support the view that the pineal satisfies certain criteria for physiological function, and further investigation into the nature of this function is necessary.

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HÆMATOLOGY

Evidence for a New Allele in the Kidd Blood Group System in Indians of Northern Mato Grosso, Brazil

A NEW phenotype in the Kidd blood group system, *Jk* (*a*–*b*–), has recently been recognized in a Filipina of Spanish and Chinese ancestry[1]. This phenotype is extremely rare in Whites and Negroes; its incidence in Asian people or their descendants has not as yet been determined. We recently had the opportunity to study the blood groups of a number of Brazilian Indians indigenous to the northern part of Mato Grosso in the region of the headwaters of the Upper Xingu River. Because of the peculiar geographical features defining this area, these Indians live in virtual isolation, and because of tribal customs, marriage is exclusively between first cousins. The present communication reports the frequency of the phenotype *Jk* (*a*–*b*–) and evidence for a new allele, *Jk*, in a sample of this population.

Venepuncture specimens were collected in sterile vacuum tubes containing acid–citrate–dextrose solution, and shipped by air to New York, where the testing was performed 3–5 weeks after the initial collection. It was possible to obtain 88 specimens from representatives of four linguistic groups. The names of these groups and the distribution of the phenotypes of the Kidd system are shown in Table 1. Because of the heretofore reported rarity of the phenotype *Jk* (*a*–*b*–), detailed re-testing was performed on the five specimens found to be *Jk* (*a*–*b*–). The cells were tested with three different anti-Jk^a sera, two anti-Jk^b sera, and with the serum of Mrs. Santos, the patient reported by Pinkerton *et al.*[1]. In all instances negative results were obtained.

Table 1. DISTRIBUTION OF PHENOTYPES OF THE KIDD BLOOD GROUP SYSTEM IN 88 INDIANS OF MATO GROSSO

Name of tribe	Number tested	Phenotypes			
		Jk (*a*–*b*–)	*Jk* (*a*+*b*–)	*Jk* (*a*–*b*+)	*Jk* (*a*+*b*+)
Carib	13	2	7	2	2
Arawak	19	0	4	7	8
Tupi	43	1	19	10	13
Trumai	13	2	4	6	1
Total	88	5	34	25	24

Calculations of gene frequencies based upon the hypothesis that only two alleles exist in the Kidd system yielded results that were internally inconsistent. The results were then recalculated on the assumption that three alleles exist, using Bernstein's method as described by Mourant[2]. The agreement between the observed and theoretical frequencies shown in Table 2 provides further evidence for the presence of a third gene, *Jk*, in the Kidd blood group system. It appears likely that this gene, though rare in Caucasians, is common in Asians and their descendants.

Table 2. PHENOTYPE AND GENE FREQUENCIES

	Phenotypes (per cent)				Genes (per cent)		
	Jk (*a*–*b*–)	*Jk* (*a*+*b*–)	*Jk* (*a*–*b*+)	*Jk* (*a*+*b*+)	*Jk*	Jk^a	Jk^b
Observed	5·68	38·64	28·41	27·27	0·2453	0·4185	0·3362
Expected	5·55	38·05	27·80	28·14			

This work was performed in part during tenure of one of us (R. T. S.) as Visiting Fulbright Lecturer, University of Bahia School of Medicine, Salvador, Bahia, Brazil.

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Role of C'_4 in the Antiglobulin Reaction

When human red cells are incubated with fresh serum containing a complement-binding blood-group antibody, they become agglutinable by an anti-'non-γ' globulin serum, that is, a serum reacting with human globulins other than γ-globulin[1-3]. In such cases the antiglobulin serum reacts with complement (C') rather than with the blood-group antibody[4].

The object of the present work was to identify more precisely the antigen and antibody concerned in this reaction: that is, the particular component of C' on one hand and the particular antiglobulin on the other.

In trying to identify the component of C' reacting with antiglobulin serum, two approaches were used. First, red cells sensitized with antibody were allowed to react with C' under conditions which permitted the formation of the complex $C'_{1,4}$ but were unfavourable to the formation of $C'_{1,4,2}$[5,6]. Secondly, sensitized red cells were treated with some components of C' supplied from human serum and other components supplied from rabbit serum. In both sets of experiments the cells were tested with antiglobulin serum (either with anti-human globulin or anti-rabbit globulin), and with immuno-conglutinin serum (I—K) of the type described by Coombs and Coombs[7] as "I—K serum (auto-stimulation)".

In the first series of experiments, sensitized red cells (for example, $Le(a+)$ red cells incubated with inactivated anti-Le^a) were treated with de-ionized serum to which either calcium or calcium and magnesium had been added. Gandini[8] has recently published the results of similar experiments. Like Gandini we found that sensitized red cells treated at 0° C. with fresh serum containing calcium but not magnesium would react with antiglobulin serum, suggesting that the adsorption of C'_2 is not necessary for a positive antiglobulin reaction. We also carried out experiments at 37° C. and found that cells treated with de-ionized serum to which only calcium had been added reacted moderately strongly with an antiglobulin serum and weakly with an I—K serum (the positive reaction of the I—K serum could be explained by the presence of small amounts of magnesium in de-ionized serum[5]). Sensitized cells treated with serum to which calcium and magnesium had been added reacted strongly with I—K serum, but the reaction with an antiglobulin serum was also improved. This enhancement of the antiglobulin reaction suggested either that the adsorption of C'_2 enhances the adsorption of C'_4 or that C'_2 itself reacts with the antiglobulin serum. In an attempt to decide between these hypotheses, a second series of experiments was done.

For these experiments preparations containing predominantly C'_1 or C'_2 were made from human serum and rabbit serum by the method of Pillemer *et al.*[9]. Human serum containing only C'_4 was prepared by heating fresh serum to 56° C. for 30 min. and then treating it with zymosan. Rabbit serum was heated only to 52° C. for 30 min. because at higher temperatures C'_4 was destroyed; the serum was not treated with zymosan since this removes all complement activity[10].

Sensitized red cells incubated with human C'_1 alone were not agglutinated by an anti-human globulin serum; but if they were first incubated with human C'_1 or rabbit C', and then incubated with human C'_4, they were agglutinated by anti-human globulin serum. Similarly, sensitized cells treated with human C'_1, then with rabbit C'_4 (and C'_2), were agglutinated by anti-rabbit globulin serum.

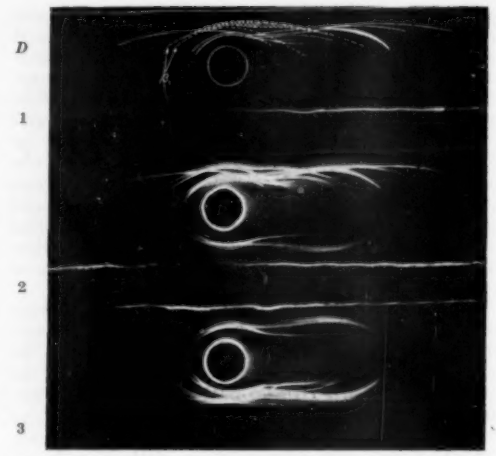

Fig. 1. Immuno-electrophoresis of normal human serum (placed in the circular cups and submitted to electrophoresis) versus anti-human globulin serum (in the longitudinal troughs 1, 2 and 3). The anti-human globulin serum was a specially selected one which only contained antibodies against α- and β-globulins (the line extending farthest to the left in the figures is due to β_2-globulin). 1, The untreated antiglobulin serum; 2, the same antiglobulin serum absorbed with 'complement-coated' cells, that is, sensitized red cells treated with human complement; 3, the same antiglobulin serum after absorption with sensitized red cells not treated with human complement; *D*, diagram of the reactions of the unabsorbed antiglobulin serum; the lines in the β_1-globulin region removed by absorption with 'complement-coated' cells are indicated by broken lines

In the case in which cells were first exposed to rabbit C'_1, then to heated, zymosan-treated, human serum, it seems clear that the only component of human complement adsorbed was C'_4, and since the cells were strongly agglutinated by anti-human globulin serum, C'_4 must be the chief and perhaps the only protein reacting with the antiglobulin serum. Nevertheless, stronger reactions with anti-human globulin serum were obtained when sensitized red cells were treated with rabbit C'_1 and C'_2 and human C'_4 than when they were treated with only rabbit C'_1 and human C'_4, so that again there is suggestive evidence that C'_2 enhances the adsorption of C'_4.

The conclusion that antiglobulin serum does not react directly with C'_1 is supported by the further observation that when sensitized red cells were incubated with fresh serum and then treated for 1 hr. at 37° C. with 0·01 *M* ethylenediamine tetra-acetic acid (treatment which is said[11] to remove virtually all C'_1 from the cells without removing C'_4), the cells still reacted strongly with antiglobulin serum.

That antiglobulin serum and I—K serum do not detect complement in the same state is known from the fact that the reactions of antiglobulin serum, but not I—K serum, are inhibited by the addition of whole serum to the reagent. A further difference may be shown by incubating sensitized cells with C' for varying periods, for after 4–5 hr. the cells no longer react with I—K serum but still react strongly with antiglobulin serum[10]; similar observations have been reported by Gandini[8]. Coombs *et al.*[12] and Gandini[8] have shown that C'_1, C'_4 and C'_2 are all needed for a positive I—K reaction. Incidentally, we have noted that in tests with an I—K serum it is common to

observe that only a proportion of the cells are agglutinated, the appearance being that of a mixture of strongly agglutinated cells and unagglutinated cells; this may be due to the fact that the complex $C'_{1,4,2}$ decays rapidly at 37° C.[13] so that only a proportion of the cells are 'coated' with the active complex.

In order to identify the antibody in the anti-globulin serum reacting with C' adsorbed on to red cells, antiglobulin sera were examined by the technique of immuno-electrophoresis, before and after absorption with 'complement-coated' cells. Sheep red cells were sensitized with bovine antibody and then incubated with fresh human serum (previously absorbed with unsensitized sheep red cells). These 'complement-coated' cells, after being well washed, were used to absorb several different anti-human globulin sera. The sera were absorbed until they no longer agglutinated red cells which had adsorbed human C'. Such absorbed sera were found to have lost lines in the β_1 region (Fig. 1). This finding is consistent with the observation of Ellis and Gell[14], who immunized rabbits with an antigen–antibody precipitate which had been allowed to adsorb human C' and obtained a serum containing predominantly an anti-β globulin; and of Matuhasi and Usui[15], who obtained anti-β_1 and anti-α_2 following the injection of human C' adsorbed on to an antigen–antibody complex.

The conclusion of Gandini[8] that the antibody reacting with adsorbed complement is anti-α_2 may have been due to the fact that the particular preparation of α_2-globulin which he used is known to contain traces of other globulins (unpublished observations). We have found that a very pure preparation of 19*S* globulin, kindly prepared by Dr. R. A. Kekwick, containing only α_2- and γ-globulin fails completely to inhibit the reaction between antiglobulin serum and 'complement-coated' cells. On the other hand, we have succeeded in inhibiting the reaction by adding a fraction of serum containing predominantly β_1-globulin, obtained from starch-block electrophoresis.

It appears, then, that the so-called 'non-gamma globulin' Coombs reaction is a reaction between C'_4 adsorbed on to red cells and a corresponding anti-β_1 globulin.

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Further Evidence for the Dual Nature of the Third Component of Complement

During the past two years there have been several reports of the complex nature of the third component of complement ($C'3$) based on its lysis of sensitized erythrocytes in the presence of the other components of complement[1–3], and Rapp *et al.*[4] have separated two factors from guinea pig serum which are both needed for the action that was previously associated with $C'3$. The existence of two such factors has also been suggested by the experiments described here.

Guinea pig serum heated to 56° for 20–30 min. fails to lyse sensitized erythrocytes that have already reacted with the first, second and fourth components of complement ($EAC'_{1,4,2}$) (see Table 1). This is not due to an anti-complementary action of heated serum, since it will not inhibit the lysis of $EAC'_{1,4,2}$ by whole guinea pig serum in the presence of 0·02 *M* versene. Classical methods of titrating $C'3$[5] using an *R*3 (whole serum from which $C'3$ has been removed by treatment with zymosan) indicated that only about 50 per cent of the $C'3$ in guinea pig serum is inactivated by heating, so that heated serum should be able to bring about the lysis of $EAC'_{1,4,2}$ unless some previously unknown heat-labile factor is also involved. Definite evidence for this factor was obtained by treating $EAC'_{1,4,2}$ (prepared according to the directions of Levine *et al.*[6]) for 15 min. at 37° with heated serum, centrifuging, resuspending the cells in *R*3, incubating for a further 15 min. at 37° and then determining the percentage hæmolysis. Table 1 shows that this leads to considerable hæmolysis, while treating $EAC'_{1,4,2}$ with the two reagents in the reverse order gives practically no hæmolysis.

Table 1. Hæmolysis of $EAC'_{1,4,2}$ by Guinea Pig Serum Reagents

Reagent (in order of reaction with $EAC'_{1,4,2}$)	Percentage of hæmolysis of $EAC'_{1,4,2}$ prepared with: guinea pig serum	human serum
Heated serum + *R*3	43	37
*R*3 + heated serum	7	12
Heated serum alone	5	7
*R*3 alone	15	17
Serum + 0·02 *M* versene*	51	—
Serum + 0·02 *M* versene + heated serum*	52	—

* Reacted simultaneously with $EAC'_{1,4,2}$

Similar results are obtained by treating $EAC'_{1,4,2}$ prepared with human serum as a source of complement by the method of Leon[7] with the two reagents from guinea pig serum. However, the analogous reagents prepared from human serum will not lyse $EAC'_{1,4,2}$ prepared with either human or guinea pig serum. *R*3 from human serum can replace *R*3 from guinea pig serum, but heated human serum cannot substitute for heated guinea pig serum in these systems.

It is suggested that the term $C'3$ should be reserved for the component of complement that is adsorbed by zymosan and is comparatively heat-stable, while the new heat-labile factor not adsorbed by zymosan which reacts last in the known series of complement components should be called the fifth component of complement ($C'5$). Work on the identification of these components with Rapp's factors *a* and *b*[4] is proceeding.

Preliminary investigations of the kinetics of the reactions of $C'3$ with $EAC'_{1,4,2}$ and of $C'5$ with $EAC'_{1,4,2,3}$ suggest that the first reaction is a fast one

and the complex $EAC'_{1,4,2,3}$ loses its reactivity with $C'5$ fairly rapidly at 37°, while the second reaction involving $C'5$ and leading to hæmolysis is a comparatively slow one. This is in apparent conflict with Rapp's demonstration of a short lag in the hæmolysis of $EAC'_{1,4,2}$ by versene-treated guinea pig serum[1] (containing $C'3$ and $C'5$), which suggests that the earlier step is rate limiting. This discrepancy would be resolved if the reaction of $C'5$ with the complex $EAC'_{1,4,2,3}$ could be shown to be slower than the lytic reaction of the sensitized erythrocyte which has already reacted with all five components of complement.

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Hæmoglobin Content of the Larvæ of *Tendipes f.l. plumosus* L. from Various Levels of Bed Sediment

In previous work[1,2] it was shown that the amount of hæmoglobin in the larvæ of *Tendipes f.l. plumosus* varies according to the amount of dissolved oxygen present. However, the results obtained cannot be considered to be particularly reliable since at various seasons the larvæ are at various stages of development, and this may have some effect on the hæmoglobin content.

In order, therefore, to prove that the amount of hæmoglobin depends on the oxygen content of the environment, I tested for hæmoglobin content larvæ from various levels of bed sediment at the same period, taking into consideration the age of the larvæ. If the amount of dissolved oxygen is larger in larvæ from the surface layer, in which oxygen content is without doubt greater than in the deeper layers, then the amount of hæmoglobin should be less in larvæ from that layer than in larvæ from deeper layers.

Tendipes f.l. plumosus larvæ were collected for analysis from the bed of the Ordynacki pond in Dojlidy (a suburb of Białystok). Specimens were taken on the day when the pond had been emptied; thus it was possible to collect them and to calculate the exact depth of the strata from which they were taken. The larvæ were collected from two layers:

Table 1. Hæmoglobin Content in the Larvæ of *Tendipes f.l. plumosus* L. from Different Layers of Sediment on the Bed of the Ordynacki Pond. Dry Mass (per cent)

Position No.	Surface layer (6 cm. deep)	Layer 10 cm. deeper
1	8·2	27·5
2	8·0	28·3
3	3·1	23·0
4	10·1	26·5
5	11·6	28·3
Average	8·2	26·7

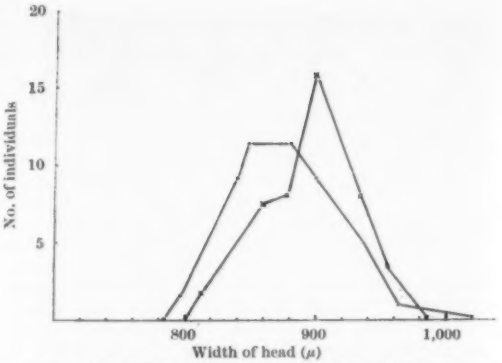

Fig. 1. Size of head of the larvæ of *Tendipes f.l. plumosus* L. .—.—.—, Surface layer (6 cm.); ×—×—, layer 10 cm. deeper

from a 6-cm. surface layer and from a layer 10 cm. below it. The hæmoglobin content was determined by the method used in the previous studies[3]. The age of the larvæ was estimated by measuring the size of their heads[4].

As a result of these studies it was found that the larvæ of *Tendipes f.l. plumosus* from the 6-cm. surface layer and those from the layer 10 cm. deeper were in the fourth stage of development (Fig. 1), despite the fact that the body measurements and weight of dry mass of one larva from the deeper layer are greater[5]. As will be seen from Table 1 there is a difference in the amount of hæmoglobin found in larvæ from the two layers of bed sediment. In the superficial layer the hæmoglobin content averaged 8·2 per cent of dry mass, whereas in the deeper layer of 10 cm. the hæmoglobin content of the larvæ varied, the average being 26·7 per cent. There is no doubt but that in the 6-cm. surface layer the oxygen content is much greater than that of the deeper layer. The fact that there is more hæmoglobin in the larvæ from the deeper layer is due to the smaller amount of oxygen there. It is characteristic that in that part of Rajgrodzkie Lake where there is least oxygen, not only is the hæmoglobin content highest and the weight of one of the larvæ heaviest but also that there is a greater concentration of larvæ found at that depth[6].

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RADIOBIOLOGY

Removal of Strontium from Milk

The importance of milk as a dietary source of calcium and other important nutrients makes it desirable to develop methods for use in removing radiostrontium from milk in the event that the concentration of the radioisotopes of strontium in this food should become a health hazard. Migicovsky[1] has

Table 1. Effect of Bone Column Treatment on Removal of Strontium-85 and Composition of Milk. (Columns: approximately 12–14 cm. × 1·8 cm.)

Bone	Amount bone (gm.) per quart milk	Calcium (m.equiv./l.)	Sodium (m.equiv./l.)	Potassium (m.equiv./l.)	Phosphorus (mgm. per cent)	Strontium-85 removed (per cent)
Control milk		55	24	39	88	
Anorganic bone treated with 4 *N* calcium chloride	25	51	21	37	89	57
Fat-free bone treated with 8 *N* potassium hydroxide	33	34	21	38	71	75
Fat-free bone treated with 4 *N* calcium chloride and 8 *N* potassium hydroxide	33	34	21	37	60	70

employed a synthetic resin in the mixed calcium, potassium, and sodium forms to remove substantial amounts of the radioisotopes of strontium and cæsium from contaminated milk. A large amount of resin to the volume of milk treated is required by this method.

Bone, owing to the fact that it contains as its mineral phase crystals of apatite, rapidly sequesters strontium ions from fluids *in vivo* and *in vitro*[2]. This property of bone has been utilized to develop a simple process for the removal of radiostrontium from milk. Various methods used in preparing bone for use have been observed markedly to affect the efficiency of the material in taking up strontium. The following have been found to be more effective than other forms of apatites: anorganic bone prepared by removal of proteins by extraction of bone with ethylene diamine[2]; fat-free bone prepared by extraction of lipids with a 50 per cent mixture of alcohol and ether; anorganic bone or fat-free bone treated with 4 *N* calcium chloride solution and the same materials treated with 4 *N* calcium chloride solution followed by 8 *N* potassium hydroxide solution. Excesses of each of the latter solutions were removed by washing the solids with water. Table 1 presents data demonstrating the efficiency of columns of pulverized modified bone (40–60 mesh) in the removal of strontium-85 added to milk. Analyses of milk before and after treatment are also given. Anorganic bone treatment produces the least alteration in milk composition and appears efficient in the removal of added strontium-85. Fat-free bone further modified, as indicated in Table 1, also has a marked ability to remove radiostrontium from milk but produces more alteration in the ionic composition of milk than anorganic bone.

10 ml. of 4 *N* calcium chloride solution will remove the bulk of the radiostrontium picked up by 10 grams of bone from milk. Potassium hydroxide does not improve the regeneration of anorganic bone column treated with calcium chloride, but it almost doubles the regeneration of a fat-free bone previously treated with calcium chloride.

The effect of treating fat-free bone with potassium hydroxide and/or calcium chloride on the efficiency of a column in removing strontium-85 added to a quart of milk is shown in Table 2. In each trial a constant flow-rate of 2 ml. per min. was maintained. As indicated a single column of modified fat-free bone can be regenerated repeatedly and is most efficient after combined treatment with calcium chloride and potassium hydroxide solutions. Anorganic bone can be repeatedly reactivated and re-used after calcium chloride treatment alone. The calcium content of milk when altered can be re-adjusted, if desired, by calcium additives. A taste panel has not reported changes in flavour of the treated milk. Greater efficiency in removal of radiostrontium by these materials should be obtained with longer columns.

Table 2. Removal of Added Strontium-85 from Milk with a Regenerated Fat-Free Bone Column (15 cm. × 1 cm. Dimensions)

Trial	Column* treatment	Percentage activity removed from milk (per quart)
1	8 *N* Potassium hydroxide	34
2	4 *N* Calcium chloride	23
3	4 *N* Calcium chloride 8 *N* Potassium hydroxide	47
4	4 *N* Calcium chloride 8 *N* Potassium hydroxide	45
5	4 *N* Calcium chloride	25
6	4 *N* Calcium chloride 8 *N* Potassium hydroxide	39

* 50 ml. of regenerating solution per trial.

It has been demonstrated in other experiments in which a gram of solid was mixed for 10 min. with 50 ml. of milk that approximately 50 per cent of the radiostrontium was removed by fat-free bone pre-treated with potassium hydroxide or by anorganic bone.

The techniques described indicate that a simple method for the commercial treatment of milk based upon these results is practical.

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Effect of Oxygen on the Radiosensitivity of Bacteriophage in the Presence of Sulphydryl Compounds

Ionizing radiation is generally more effective in killing cells if oxygen is present at the time of irradiation[1]. In view of the variety of the organisms in which the injury appears to be associated with the genetic apparatus[2], it is surprising that no oxygen effect should be found when bacteriophage[3] and transforming principle[4] are irradiated in an aqueous suspension containing nutrient broth or other material to protect them against indirect radiation effects.

The suggestion that a hydrogen donor may be responsible for the reduced sensitivity found under anoxia has been put forward on chemical grounds[5], and a similar conclusion has been reached from an analysis of the kinetics of the effects of oxygen and nitric oxide on the radiosensitivity of bacteria[6]; but direct evidence in support of the role of a hydrogen donor in the oxygen effect in a biological system has been lacking.

Two observations have directed attention to the sulphydryl compounds in this connexion. Cysteine[7] and cysteamine[8] gave added protection to *T2* bacteriophage, which appeared to be already fully protected by nutrient broth. In an attempt to elucidate this effect, an investigation has been made into the effect of known concentrations of oxygen and cysteamine on the radiosensitivity of bacteriophage protected from indirect action. Similar experiments have been carried out with the *T2* *E. coli B* complex formed by the adsorption of *T2* to the host cell.

Wild-type *T2* bacteriophage were irradiated in aqueous suspension, diluted in nutrient broth, plated in a layer of soft agar seeded with *E. coli B* and incubated at 37° C. It was found that thiourea was more effective than nutrient broth in protecting the phage against indirect effects of irradiation, and was convenient in that it did not froth when bubbled with a gas. Thiourea was without toxic effect even at high concentration, so long as it was adequately diluted before plating. The complexes were prepared from a logarithmic phase culture of *E. coli B* which was infected at a multiplicity of about 0·02 phage per bacterium in the presence of cyanide. Phage which had not adsorbed were inactivated with antiserum. The irradiations were carried out at 30,000 rads per min. with 8-MeV. β-rays at 2° C. As both cysteine and cysteamine oxidize at *p*H 7, care was taken to see that the oxidation to the disulphide form and the resulting depletion of oxygen did not influence the results of the experiment. Samples of the suspension were placed in an irradiation vessel which had a glass filter base. To control the amount of oxygen present, either oxygen or oxygen-free nitrogen was passed through the filter so that it bubbled through the suspension. Thus anoxia was ensured by the nitrogen stream, independently of the presence of the sulphydryl compound. When oxygen was bubbled through the suspension containing cysteamine, some oxidation occurred. At the end of the irradiation, after bubbling with oxygen for a total period of about 10 min., the amount of

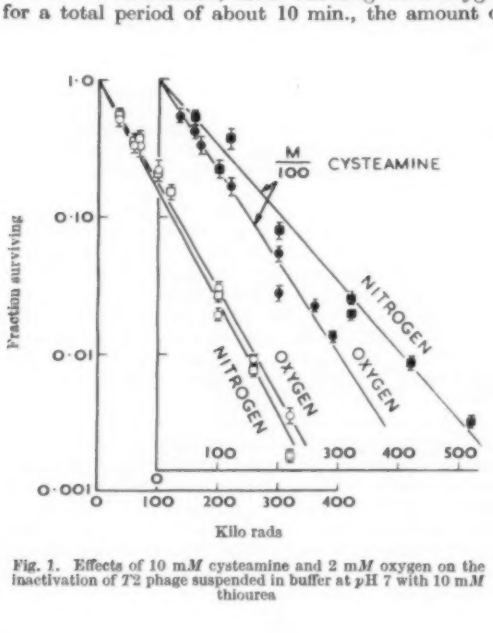

Fig. 1. Effects of 10 m*M* cysteamine and 2 m*M* oxygen on the inactivation of *T2* phage suspended in buffer at *p*H 7 with 10 m*M* thiourea

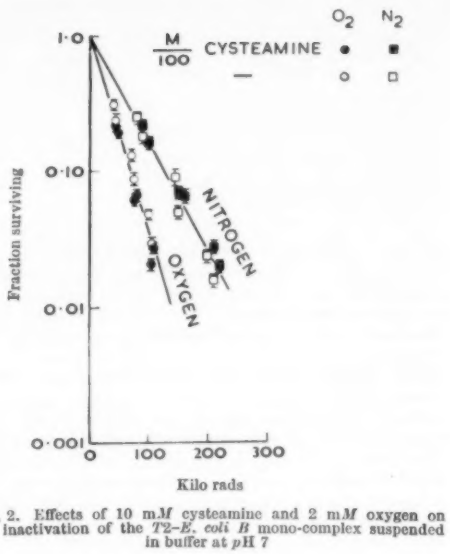

Fig. 2. Effects of 10 m*M* cysteamine and 2 m*M* oxygen on the inactivation of the *T2*–*E. coli B* mono-complex suspended in buffer at *p*H 7

—SH remaining was found to be more than 60 per cent of the initial concentration, as estimated by the nitroprusside method[9]. Studies of the rate of equilibration of the dissolved gases in a similar bubbling vessel indicated that the concentration of oxygen fell by a factor of 100 in 40 sec. when nitrogen was bubbled through a suspension containing oxygen. It was estimated that at this rate of equilibration the amount of oxygen consumed in the oxidation of the cysteamine would reduce the oxygen concentration by less than 10 per cent below the equilibrium value of 2 m*M*. Thus, during the period of the irradiation, the concentration both of cysteamine and oxygen was known to lie within certain limits.

The combined results of duplicate experiments are shown in Fig. 1. It is seen that the rate of inactivation of *T2* bacteriophage protected by 10 m*M* thiourea was almost independent of the oxygen concentration. On adding cysteamine, there was a marked decrease in the inactivation rate under nitrogen, although most of the effect was abolished in oxygen. These results strongly suggest that oxygen competes very effectively for the radiation-induced injuries in the phage deoxyribonucleic acid which can be restored by the cysteamine. It seems unlikely that the protective effect of cysteamine is due to an improvement in the degree of anoxia to which the phage were subjected, as cysteamine was equally effective in sealed ampoules in the presence of sodium dithionite, which combines rapidly with oxygen at *p*H 7, while the dithionite by itself was without effect. The disulphide form cystamine was not active[8], but cysteine and cysteamine were about equally effective in causing anoxic protection.

It is of interest that after the host *E. coli B* has adsorbed *T2* phage, the complex so formed is about twice as radiosensitive in oxygen as it is when anoxic[6,10]. As shown in Fig. 2, 10 m*M* cysteamine is without effect on the sensitivity of either the aerobic or anoxic complex. Metabolic steps are not involved in the development of the oxygen effect, since it occurs even if the adsorption takes place in the presence of cyanide.

It appears that an oxygen effect is observed when the phage deoxyribonucleic acid is in the presence of substances with labile hydrogen groups. With free phage, cysteamine or cysteine is effective, while in the case of the phage–bacterium complex, it may be that intra-cellular sulphydryl compounds or other hydrogen donors are involved. The degree of the injury sustained in an irradiation appears to depend upon competition between oxygen and the hydrogen donor[6], presumably for a carbon radical induced by radiation in the phage deoxyribonucleic acid. If this is true, the action of the hydrogen donor is to replace a hydrogen atom on the deoxyribonucleic acid which had been removed by ionization or by radical attack, thus restoring the deoxyribonucleic acid molecule to the active form. The oxygen effect observed with the free phage is smaller than that found with the complex. The explanation of this difference may lie in the difficulty which the sulphydryl compound (or oxygen) may experience in penetrating the phage head membrane and the tightly packed nucleic acid. If these substances are unable to diffuse freely over the surface of the deoxyribonucleic acid molecule, there will be reduced opportunity for reaction with a radiation-induced injury, so that a smaller oxygen effect might be expected. There is some evidence for this explanation in the finding that mature intracellular phage particles show no oxygen effect (unpublished work). If this is the correct explanation, then it is to be expected that transforming principle would show an oxygen effect in the presence of a sulphydryl compound and that the effect might be larger because of greater accessibility to the nucleic acid.

In summary, the reason why oxygen is without effect on the X-ray inactivation of bacteriophage in protective suspension lies in the absence of a suitable hydrogen donor such as a sulphydryl compound. A second factor is that some compounds may experience difficulty in penetrating into the compact structure of the phage head. The oxygen effect on the X-ray inactivation of the complex is presumably a reflexion of the competition between molecular oxygen and intra-cellular hydrogen donors, such as sulphydryl compounds, for the radicals induced by radiation in the phage nucleic acid.

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Yeast Ribonucleic Acid and its Nucleotides as Recovery Factors in Rats receiving an Acute Whole-Body Dose of X-Rays

It has recently been shown that ribonucleic and deoxyribonucleic acids injected in rats and mice can markedly influence the post-irradiation survival[1–3]; but the exact nature of the mechanism responsible for this beneficial effect is at present unknown. An attempt has been made to give a partial answer to this problem by studying the restorative effect of a ribonucleic acid extracted from yeast, as well as the products of a progressive degradation by controlled alkaline hydrolysis of the same substance, upon rats which had received a single whole-body dose of X-rays. The selected irradiation dose corresponded approximately to the *LD*85(30) for the control animals the death of which was due to acute damage caused to hæmatopoietic tissues. The 30-day survival of the treated animals was taken as a criterion of effectiveness.

The rats used in the experiments were 4 months old male albinos, of an inbred strain raised in the Institute, the body-weight of which varied from 140 to 150 gm. The animals were left un-fed overnight, then irradiated in groups of 4 contained in a 'Lucite' box which was revolved at 2·5 r.p.m. The X-ray unit was a G.E. Maxitron operated at 250 kVp. and 25 m.amp., equipped with a beryllium end-window and additional 0·25 mm. copper + 1 mm. aluminium filters. The half-value layer was 1·15 mm. copper. At a target distance of 80 cm., the delivery-rate averaged 40 r./min. as measured in air with a Victoreen Radocon dosimeter.

The trial solutions, adjusted to a *p*H of 6·5–7, were injected intraperitoneally at a constant volume of 2 ml. per animal. Their tonicity was determined by the freezing point depression method and equalized by the addition of appropriate amounts of sodium chloride with the tonicity of sodium chloride 150 m*M*. 2 ml. of this latter solution were injected into each animal of the control series. 24 hr. after the irradiation, the rats were given an unlimited standard diet. The subsequent mortality-rate and body-weight modification were checked at daily intervals during the 30-day period following the X-ray exposure. Dead animals were subjected to autopsy, and the survivors have been kept for a study of long-term effects.

In the first series of experiments, a dose of 100 mgm. of sodium ribonucleate, corresponding to 72 mgm. of pure ribonucleic acid, was injected within 15 min. of irradiation. Table 1 (rows *A* and *B*) shows the results observed at different X-ray levels between 450 to 550 r. It is clear that the treatment reduces the subsequent mortality-rate. Probit analysis[4] of the results allows the following regression equations to be calculated: $Y = -57{\cdot}05 + 23{\cdot}05 \log_{10} r.$ for the treated animals, and $Y = -41{\cdot}82 + 17{\cdot}72 \log_{10} r.$ for the controls, in which Y is the probit of the percentage of 30-day mortality and r. the X-ray dose in roentgens. There is no significant difference between the regression coefficients. The *LD*50(30) derived from the previous equations are respectively 492·3 r. (5 per cent fiducial limits 504 and 481·5) and 438·7 (5 per cent fiducial limits 451·2 and 427). They differ very significantly from one another ($P < 0{\cdot}001$). Calculation of the corresponding dose-reduction factor gives a value of 1·12. It is noteworthy that a dose-reduction factor of the same order of magnitude,

Table 1. Effects of Injection of Yeast Ribonucleic Acid on the 30-day Mortality of Rats

	X-ray dose (r.)	Number of rats: Per group	Number of rats: Total	Mortality at 30 days (per cent): Per group	Mortality at 30 days (per cent): Total
A. Control series* injected with 2 ml. of saline	550	20	20	100	100
	500	20, 20, 20 20, 20, 20 20, 24, 20	184	85, 80, 75 75, 70, 95 100, 70·8, 85	81·5
	450	10, 12, 20, 20	62	50, 75 70, 75	69·4
	400	20, 20	40	10, 25	17·5
B. Sodium ribonucleic acid (Merck)† injected at a dose of 100 mgm. in 2 ml. saline per animal within 15 min. of irradiation	550	20, 12, 12	44	85, 100, 95	90·9
	500	20, 20 20, 8	68	50, 45 65, 37·5	51·5
	450	20 20	40	25 15	20
C. Sodium ribonucleic acid (Merck)† injected at a dose of 100 mgm. in 2 ml. saline within 15 min. prior to irradiation	500	20 20 20	60	50 60 80	63·3
D. Ribonucleic acid (BDH)‡ injected at a dose of 80 mgm. in 2 ml. saline within 15 min. of irradiation	500	20 20	40	50 50	50

* At each level of irradiation (excepted, 550 r.), the control series include groups injected with saline solution either before or after irradiation. As statistical examination of their mortality after 30 days failed to reveal any difference between the pre- and post-treated groups, it was considered feasible to combine them in a single control group, valid for comparison with the ribonucleic acid pre- and post-injected animals.

† Obtained from Merck Co., Darmstadt, Germany, as the sodium salt of yeast ribonucleic acid. Following the method of Ogur and Rosen (ref. 6) the product has been found to contain 72 per cent of pure ribonucleic acid and 2 per cent of deoxyribonucleic acid. Traces of protein material have been detected.

‡ Ribonucleic acid from yeast, British Drug Houses, Ltd., England. It is converted into its sodium salt by addition of appropriate amount of sodium bicarbonate at 0° C. and injected at a dose corresponding to the ribonucleic acid content of the 'Merck' preparation. Both these products, of different commercial origin, seem equally effective.

1·17, has been reported for the protective effect of cysteamine on the hæmatopoietic tissues of the same strain of rats[5].

While demonstrating the restorative effects of ribonucleic acid, the above results do not by any means exclude the possibility that this product can also exert a protecting action. To elucidate this point 3 groups of 20 rats were first injected with a similar dose of 100 mgm. sodium ribonucleic acid, then irradiated with 500 r. 15 min. afterwards (Table 1 row *C*). Comparison of their 30-day mortality with those of animals injected after irradiation shows the post-irradiation treatment to be at least as effective as the pre-irradiation treatment. A χ^2 test, in the formula of which the Yates correction of continuity was incorporated[9], failed to reveal any significant difference between these two treatments (calculated $P > 0{\cdot}1$). Therefore, it seems very likely that ribonucleic acid, injected intraperitoneally, acts purely as a recovery factor, without any additional protective effects.

Further experiments were conducted to determine whether the effectiveness of ribonucleic acid is retained after partial degradation of the molecule into nucleotides by controlled alkaline hydrolysis. Two preparations were tested. The first, in which intermediate products were still abundant, was obtained under very mild conditions, while the second consisted of an almost pure mixture of mononucleotides. A comparative inspection of Tables 1 and 2

Table 2. Decrease of the 30-day Mortality of Rats irradiated with 500 r. by Injection of 2 ml. of Alkaline Hydrolysate of Ribonucleic Acid*

Composition of hydrolysates† (per cent)		Moment of injection	Number of rats: Per group	Number of rats: Total	Mortality at 30 days (per cent): Per group	Mortality at 30 days (per cent): Total
I Oligonucleotides:	70	Within 15 min. of irradiation	20 20	40	30 30	30
Mononucleotides:	28					
Residual ribonucleic acid:	0					
		Within 15 min. prior to irradiation	20 20	40	45 45	45
II Oligonucleotides:	5·7	Within 15 min. of irradiation	20 20	40	50 50	50
Mononucleotides:	87·3					
Residual ribonucleic acid:	0					
III Control series				184		81·5

* Solutions were made up so that their content in nucleotides corresponded to a concentration of 50 mgm./ml. of non-depolymerized 'Merck' sodium ribonucleic acid.

† Hydrolysate I was prepared by incubating 1 part of sodium ribonucleic acid 'Merck' with 8 parts of 0·33 *N* sodium hydroxide for 16 hr. at 24° C. Hydrolysate II was prepared according to the method of Davidson and Smellie (ref. 7). Further acidification by perchloric or trichloracetic acid did not give any precipitation in either solution, but caused a slight opalescence due to a trace of deoxyribonucleic acid. A non-mononucleotide fraction was, however, still present and was demonstrated by paper chromatography. The relative concentration of the non-mononucleotide material and the mononucleotide mixture was afterwards analysed by the method of Smith and Allen (ref. 8).

shows that both these hydrolysates are equally as effective as the native ribonucleic acid and leads to the conclusion that the recovery effect of this substance does not depend upon the integrity of its molecular structure.

The precise action of ribonucleic acid and its biochemical bases are under investigation at the moment and a full account of this work will be published elsewhere.

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BIOLOGY

The Redpoll in New Zealand: Interbreeding Sub-species

Since the opportunity of studying an animal population in which interbreeding and genetical mixing between two hitherto good and mainly allopatric sub-species is taking place must be relatively uncommon, it may be of interest to report on the discovery and preliminary investigation of a situation of this kind occurring in New Zealand.

The redpoll (F. Fringillidae : Aves) was introduced into various parts of New Zealand from about 1862 onwards[1]. The taxonomic status of the introduced birds was originally determined only to the species-level : *Carduelis flammea* (L.) (the present generally accepted nomenclature is used here, following Witherby *et al.*, 1938, "The Handbook of British Birds"). In 1953 Westerskov[2], on the basis of wing and bill measurements and details of plumage coloration of 36 skins collected in New Zealand and some adjacent islands, concluded that only one sub-species, *C.f. cabaret* (P. L. S. Mull.), was present. In the course, however, of an investigation of the ecology of the redpoll and other introduced fringillid species in Canterbury, New Zealand, it has been found necessary to modify Westerskov's conclusion. It appears that at least one other sub-species, notably *C.f. flammea* (L.), is present in the New Zealand populations.

The distinguishing features of the two sub-species *C.f. flammea* and *C.f. cabaret* are given in Table 1.

Table 1. DISTINGUISHING FEATURES OF THE SUB-SPECIES *C. f. flammea* AND *C. f. cabaret*

(After Westerskov, 1953, following Salomonsen, 1928, and Witherby *et al.*, 1938)

	Wing length (mm.)		Bill length (mm.)		General plumage colour	Wing-bar	Body-size
	M	F	M	F			
flammea	71–79	69–76	8–10	7·7–9·1	Paler	Conspicuous whitish	Slightly larger
cabaret	67–73	63–69	8–10	8–9·5	Darker	Inconspicuous buff	Slightly smaller

Observations made on approximately 170 living birds are summarized in the form of frequency-distribution curves for male and female wing-lengths, Fig. 1. The symbols *W* and *p* are given to show the occurrence, at various wing-lengths, of white wing-bar and pale plumage respectively (that is, the occurrence of *flammea*-type plumage characteristics). Reference to bill-length and body-size has been omitted, since nothing significant on these has been obtained in the present sample.

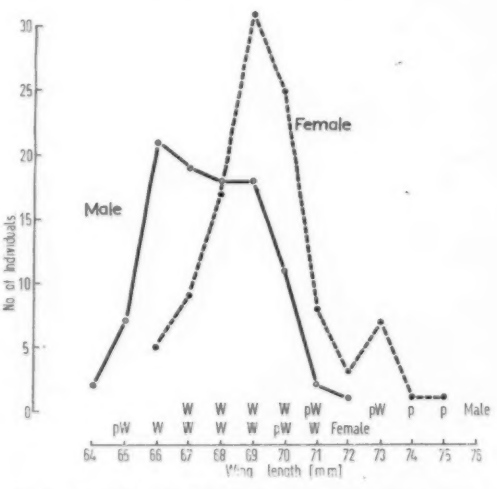

Fig. 1 Redpolls' wing-lengths – frequency distribution curves. *W*, Whitish wing-bar ; *p*, pale plumage

On comparison of Fig. 1 with Table 1, the following points will be noted : (1) The occurrence of individuals above the upper limits of the *cabaret* range of wing-lengths, for both sexes. (2) The absence of individuals in the higher portions of the *flammea* range. (3) The shift of the centres of gravity of the areas enclosed by the curves above the vicinity of the mean for *cabaret*. (4) The occurrence of *flammea*-type plumage characteristics (denoted by *W* and *p*) below the wing-length range for that sub-species.

From the conjunction of these features it seems apparent : (*a*) that the bulk of the population is composed of *cabaret*-type individuals ; (*b*) that a proportion of *flammea*-type individuals, perhaps 10–15 per cent of the population, is present ; (*c*) that the two types are interbreeding, resulting in the mixing of characteristics, for example, the occurrence of *W* and *p* with short wings, etc. (On several occasions, however, small groups of *flammea*-type individuals have been taken together. This suggests that there may still be some tendency to segregation.)

An explanation of the observed deviations from the typical *cabaret* characteristics, alternative to the assumption that one of the larger sub-species is present, may be mentioned in order to be dismissed. The alternative explanation is that the observed deviations from *cabaret* characteristics may be due to an evolutionary change within a pure *cabaret* population. It must be pointed out that this change must have been extremely rapid (the New Zealand populations have been isolated for less than a century) ; that selection pressure must have been low during this time of generally rapid expansion of the populations ; that the direction of the changes, increased wing-length and paler coloration, are the opposite of what would be expected, in an environment on the whole warmer and not less humid than the original, according to Bergmann's and Gloger's rules ; that the simultaneous evolution of several of the characteristics of another sub-species is in any event unlikely, much more so in the present case when the previously mentioned points are considered.

It may be noted that another of the introduced bird populations of New Zealand, that of the yellow-hammer, *Emberiza citrinella* L., is now thought to be a mixed population of more than one sub-species, where previously it had been considered that only the British sub-species was present in New Zealand[3].

A number of points still await clarification. It is not yet certain, for example, that the large sub-species is actually *flammea*. The uncertainty arises out of the mixing of characteristics due to inter-breeding. This sub-species seems much the most likely component of the present mixed population on the grounds of the observed characteristics (other possible sub-species are even larger than *flammea*—their absence cannot at present be asserted, of course, and in fact slight evidence has been obtained that a very few individuals of one or more or these larger sub-species may be present) and the fact that it is the only sub-species apart from *cabaret* which is found regularly and in appreciable numbers in Britain, the presumed place of origin of the New Zealand populations. (This last presumption is of course very much open to doubt.) It would be interesting, also, to ascertain what were the original proportions of pure *cabaret* and pure *flammea*, if that could be done. The present distribution of the various

types will be investigated—this may yield information as to possible modification of the presumed previously existing geographical, behavioural and ecological segregating mechanisms between the two sub-species.

This investigation is continuing, and results will be reported and discussed in full elsewhere.

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Yolk Formation in Oocytes of *Patella coerulea* L. and *Aplysia depilans* L. as observed in the Electron Microscope

Electron microscope research on vitellogenesis has so far been mainly concerned with the identification of the precursors, or cellular constituents, from which the yolk formation begins[1–5]. The origin of the yolk and further stages in its formation in oocytes of *Patella coerulea* and *Aplysia depilans* are described here. Small fragments of the female gonads were fixed in a 1 per cent solution of osmium tetroxide at *p*H = 7·4 for 1 hr. Other technical details are reported in a previous paper[6]. Preparations and observations were made at the Centre for Electron Microscopy at the University of Padua with a Siemens Elmiskop I*a* apparatus.

In the oocytes of *Patella coerulea*, at the beginning of vitellogenesis, it is possible to observe a reticulum of filaments about 200 Å. thick, which carry dark granulations about 300 Å. in diameter (Fig. 1). Some reticular cavities show a dark content, which gradually increases with the growth of the oocytes, and gives rise to well-formed proteic yolk globules showing an oval form (Fig. 2). Isolated or clustered granulations on their surface appear to enter the developing globules (Fig. 2). They are totally absent when the globules have reached their full development and only the filaments remain (Fig. 3). Previous experiments with ribonuclease showed that granulations are formed mostly by a ribonucleic complex[7].

In the oocyte of *Aplysia depilans*, vitellogenesis starts with the transformation of Golgi bodies or dictyosomes into small globules. They are surrounded, at a given stage, by a semi-lunar structure, which is formed by particles (Fig. 4) of about 950 Å. in diameter. Each particle shows a central clear zone and a peripheral zone which is composed of dark granulations with a diameter of about 300 Å. Many particles strictly adhere to the surface of the globules and it appears that granulations penetrate them (Fig. 4). When the globules are more developed, they show another semi-lunar structure, which is composed of a very dense reticulum (Fig. 5). Some of the biggest globules show some vacuoles (Fig. 5), the presence of which confirms a liquefaction process, which has been previously described[8–10]. Each globule then divides into very minute granules (Fig. 6), which find a place in the cavities (Fig. 7) of the surrounding reticulum. They finally aggregate to give origin to the definitive yolk (Fig. 7).

The electron microscope results give a fair explanation of previous optical microscope observations, which were made both in *Patella coerulea*[11] and in *Aplysia depilans*[8,9]. A very fine alveolar structure of the cytoplasm was observed in the former species along with variations in basophily, and a transformation of dictyosomes into yolk globules was described in the latter. This transformation appeared to be followed by a considerable growth of the globules, which divide to give rise to the smaller globules. Dictyosomes must thus be considered as true precursors in *Aplysia depilans*; no precursors in a strict

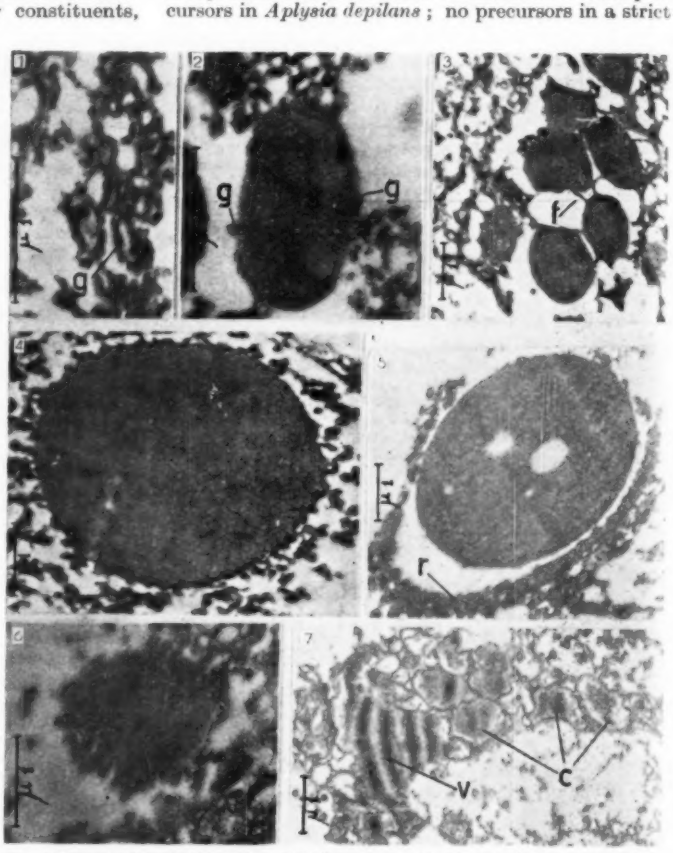

Fig. 1. Ergastoplasm in the oocyte of *Patella coerulea* with dark 300-Å. granulations (*g*). Fig. 2. Yolk globule of *Patella* oocyte with granulations (*g*) on its surface. Fig. 3. Yolk globules of *Patella* oocyte surrounded by filaments (*f*) without dark granulations. Fig. 4. Yolk globule of *Aplysia depilans* oocyte with particles on its surface. Fig. 5. Yolk globule of *Aplysia* oocyte with two vacuoles and a very dense semi-lunar network (*r*). Fig. 6. Yolk globule of *Aplysia* oocyte, which divides into very minute granules. Fig. 7. Cavities (*c*) in *Aplysia* oocyte with granules in aggregation and definitive yolk (*v*)

sense exist in *Patella coerulea*, where vitellogenesis takes place directly from the ergastoplasm.

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Sex Difference in Accidental Mortality of Guppies exposed to Elevated Temperature

Mass mortalities of fish exposed to low[1–6] and high[7–10] temperatures in Nature have been reported; but no sex differences in such incidents appear to have been recorded. The omission of data on sex ratios may be due to the fact that their interpretation would generally be unsatisfactory since the sex ratios of the original populations would be unknown, and even slight differences in habits of the sexes might result in their exposure being significantly different. In the present instance, interpretation is easier because the exact number of adults of each sex before and after exposure is known.

Over a week-end the temperature of the laboratory in which about 2,000 guppies of unnamed strains being developed for experimental purposes were housed was accidentally raised. At the time the accident was discovered the temperatures in aquaria ranged up to 41° C. and about 150 adult and many young fish were dead. Some adult fish survived in 14 aquaria in which deaths occurred and in which there were adults of both sexes. The results of observations on fatalities and survival among adults in these aquaria are presented in Table 1. Generally, if both immature fish and adults were present the former were almost all dead if any adults were; and in one tank with several large females as well as smaller ones, the smaller ones died and the large ones all survived.

Table 1. Comparison of Survival of Adult Male and Female Guppies exposed to Elevated Temperature

	Male		Female	
	No.	Per cent	No.	Per cent
Surviving	10	32	47	81
Dead	21	68	11	19

The difference in the mortalities of adults of the two sexes has been examined using the chi-square test and found to be statistically significant ($P < 0{\cdot}002$ using the two-tailed test).

The observations here reported agree with the usually observed higher mortality of males[11] and with the laboratory observations of Gibson[12] on survival times of guppies at 37°, although they do not agree with her results at other temperatures. She found that the mean time to death of guppies at 37° was about 50 per cent higher for females than for males. At 34°, on the other hand, the time to death was greater for males (5,660 min.) than for females (3,400 min.) and at other temperatures (35°, 36° and 38°) she found no sex differential.

Before the mass mortality here reported, the sex ratio for adults in the aquaria was 54 males per 100 females; after the accident, 21 males per 100 females. (The original ratio cannot be interpreted as a 'natural' one for some aquaria contained mated groups that had been selected, and fish had been removed from others for experimental purposes.) The observations on this laboratory population suggest that elevations of temperature such as occur in small, shallow, unshaded ponds may bring about significant alterations of the proportions of the sexes.

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Stereobalanus, a Genus New to the Old World

During a faunistic survey of all the lochs on the west coast of Scotland from Cape Wrath to the Solway, several pieces and some whole specimens of a golden yellow enteropneust were discovered in bottom samples taken with a 1/10 Van Veen grab (Fig. 1). The geographical location and bathymetric distribution of these specimens are given in Table 1.

In the first four localities the substratum consisted of a layer a few cm. thick of black glutinous mud overlying a stiff clay, but in Loch Glendhu it consisted of a mixture of small stones and mud. As the sampling intensity in all the lochs examined was fairly uniform, it is evident that the species is moderately common and widely distributed along the west coast

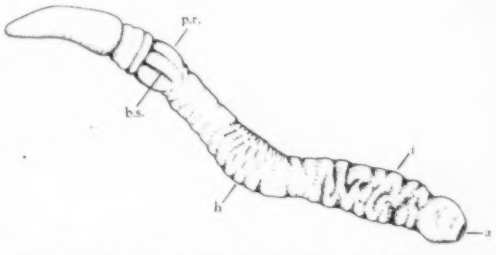

Fig. 1. *Stereobalanus* sp. Line drawing from photograph of live specimen. Overall length, about 8 cm. *a*, Anus; *b.s.*, common branchial slit; *h*, olive green hepatic region; *s*, sac-like intestinal region; *p.r.*, parabranchial ridges

Table 1. Distribution of Specimens from West Coast Lochs

Area	Position	Depth (fath.)	Date	No. of specimens
Loch Spelve (Mull)	56° 24·3′ N. 5° 43·5′ W.	8	5.6.57	1
Loch Spelve (Mull)	56° 24·1′ N. 5° 43·5′ W.	9	7.10.58	2
Loch Sunart (Glenmore Bay)	56° 40·8′ N. 5° 55·9′ W.	9	11.6.57	1
Loch Erisort (Lewis)	58° 7·4′ N. 6° 23′ W.	20	15.10.58	3
Loch Glendhu (Sutherland)	58° 15·4′ N. 4° 57′ W.	7	22.10.58	1

of Scotland and perhaps significant that it was not found in any of the samples taken south of Mull. A preliminary analysis of the associated fauna expressed as numbers per 1/10 m.² is summarized in Table 2.

The pronounced radial arrangement of the longitudinal muscles and thick enveloping layer of circular muscles and reduced condition of the coelom in the proboscis, the absence in the mesosoma of complete dorsal and ventral mesenteries and collar pores, the very prominent dorso-lateral and ventro-lateral parabranchial ridges enveloping the branchial apertures, the rudimentary peripharyngeal cavities and the absence of any trace of œsophageal pores, justify the identification of this enteropneust as a species of the genus *Stereobalanus* Spengel.

The type material upon which this genus was established was first dredged off Cape Breton, Nova Scotia, in 1873, by the late Prof. W. C. McIntosh, and originally named *Balanoglossus canadensis* by Spengel[1]; afterwards, in a review of the nomenclature of certain of the Enteropneusta, Spengel established a new genus for this species and it became *Stereobalanus canadensis*[2]. It was later rediscovered by Reinhard[3] some 430 miles away from the type locality at the mouth of Sullivan's River, Frenchman's Bay, Maine, where it occurred in considerable numbers in a 'soft, fine mud' substratum together with *Corymorpha pendula*, *Nephthys caeca* and *Ctenodiscus crispatus*. It has also been found at San Diego, California (Bullock, T. H., and Rao, K. P., unpublished work).

The only other species of the genus recorded (*S. willeyi* Ritter) was found in San Pedro Channel, New Port, California, where fragments of specimens were discovered in very soft sandy mud taken from a depth of about 40 fm.[4].

Table 2. Analysis of the Associated Fauna

Animal	Numbers per 1/10 m.²			
	Spelve	Erisort	Glendhu	Sunart
Mysella bidentata (Montagu)	87	1	—	—
Other lamellibranchs	3	3	5	1
Loricata	—	—	7	—
Heterocirrus sp.	53	—	—	46
Pholoe minuta (Fabricius)	2	1	1	—
Eumenia crassa Oersted	3	—	1	—
Nephthys hystricis McIntosh	4	2	—	4
Notomastus latericeus M. Sars	1	—	2	1
Lumbriconereis hibernica McIntosh	2	4	4	—
Glycera sp.	—	2	4	—
Other polychaetes	10	20	25	6
Amphiura filiformis (O. F. Müller)	17	48	1	—
Amphiura chiajei Forbes	1	19	1	2
Other echinoderms	—	5	1	—
Ampelisca diadema (A. Costa)	1	1	2	—
Other amphipods	—	1	—	—
Cumacea	—	1	—	—

Although the specificity of the Scottish species cannot be determined without a more detailed comparative study, a preliminary examination of the general anatomy shows that it is more closely allied with *S. canadensis* than with *S. willeyi*.

Hitherto, the genus has been indigenous to the east and west coasts of North America. Its discovery in a comparable habitat in the Old World is therefore of considerable interest, and if it proves to be *S. canadensis* then it will provide yet another instance of the discontinuous distribution recorded for certain members of this phylum. It also makes an important addition to the number of Enteropneusta already recorded from the British Isles[5,6].

We are grateful to Prof. T. H. Bullock and Dr. K. P. Rao for a copy of their manuscript on this genus, and to Dr. J. S. Ryland for his assistance with the collection and preservation of the material and also for taking the photograph from which Fig. 1 was drawn.

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Effect of a Sewage Effluent Discharge on the Deposition of Calcium Carbonate on Shells of the Snail *Potamopyrgus jenkinsi* (Smith)

During an ecological survey of the River Ivel[1], a chalk stream in Bedfordshire, it was observed that shells of the snail *Potamopyrgus jenkinsi* (Smith) were heavily encrusted with calcareous nodules upstream of a sewage effluent discharge whereas downstream of the discharge such shells were clean (Fig. 1). Above the sewage effluent, snails were more than 70 per cent heavier than those below the effluent (Table 1).

Table 1. A Comparison of Weights of Snails taken from above and below the Sewage Effluent (Average of 12 Determinations)

Location	Width of shell aperture (mm.)	Dry weight (mgm.)	Calcium carbonate (mgm.)
Above effluent	1·50	2·98	2·44
Below effluent	1·46	1·73	1·42

Snails taken from below the discharge and placed in cages above it developed encrustations within three weeks. Warwick[2] referred to calcareous encrustations found on *P. jenkinsi* in a limestone district of Derbyshire but no demarcation of habitat effect was observed. Deposition also occurred on

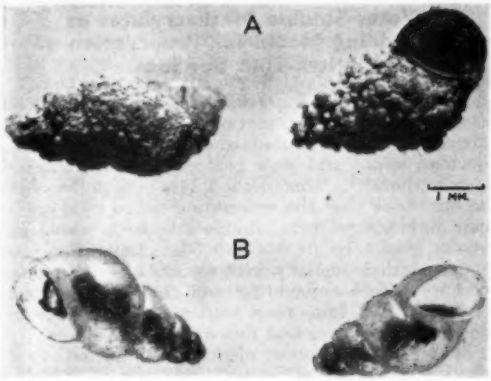

Fig. 1. *Potamopyrgus jenkinsi* shells from an unpolluted stretch of river showing calcareous encrustations (*A*) and from a polluted stretch (*B*)

glass slides immersed in the River Ivel upstream of the effluent. The *p*H value of the river water both above and below the effluent varied between 7·9 and 8·3 on the several occasions on which it was determined. Total hardness was about 290 p.p.m. as calcium carbonate. The algal flora on the snail shells was dominated by *Cocconeis* and '*Chantransia*' both upstream and downstream of the discharge. The effluent was of good quality (Table 2) and constituted between 5 and 10 per cent of the dry summer flow.

Table 2. Analysis of Sewage Effluent

	Concentration (p.p.m.)	Number of samples
Organic carbon (as C)	22	3
Ammonia (as N)	1·7	2
Nitrite (as N)	0·1	2
Oxidized nitrogen (as N)	70	2
Phosphate (as P)	10·3	3
Synthetic detergent (as 'Manoxol O.T.')	5·2	4
Permanganate value	7	2
3 day B.O.D.	11	2
Suspended solids	10	2

Laboratory experiments were conducted in which glass slides were immersed in: (*a*) river water; (*b*) river water plus sewage effluent (5 per cent by volume); (*c*) river water plus synthetic sewage effluent containing no synthetic detergents[3] (5 per cent by volume); (*d*) river water plus sodium carboxymethyl cellulose (5 p.p.m.); and (*e*) river water plus sodium hexametaphosphate (1 p.p.m. as phosphorus) at *p*H 8·2 and 8·5.

Deposition occurred only on those slides immersed in river water without additives. The sample of sewage effluent used in the above experiments contained 52 p.p.m. total organic carbon, 4·5 p.p.m. synthetic anionic detergent (as 'Manoxol O.T.'), and 5·2 p.p.m. phosphate (as phosphorus). The synthetic sewage effluent contained 24 p.p.m. total organic carbon and 2·6 p.p.m. phosphate (as phosphorus).

It is evident that sewage effluents contain several constituents which prevent the deposition and aggregation of calcium carbonate under conditions similar to those prevailing in the River Ivel. Certain constituents of packaged detergents and soaps, such as condensed phosphates which sequester calcium and magnesium ions and act as dispersive agents, and organic soil suspenders such as sodium carboxymethyl cellulose[4] may be of importance. It seems likely, from experiments with sewage effluent prepared without synthetic detergents, that other agents inhibiting deposition are also present. Similar conclusions were drawn by Alekin and Moritschewa[5] from their observations on the Don and Volga. It would seem, from their work, that certain organic substances present in these waters are inhibitors of calcium carbonate deposition, particularly humus material of plant origin.

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Occurrence of *Halimeda opuntia* var. *minor* on Jamaican Shores

I wish to report the presence of *Halimeda opuntia* var. *minor* on Jamaican shores. The variety was confirmed by Miss Lena Pierce at the Institute of Jamaica.

It was found in water 1–2 ft. deep, at the eastern end of the barrier reef protecting the west harbour at Port Antonio, in the passage between the reef and Navy Island, on July 17, 1959.

It is not common, but several clusters are scattered around and easily distinguished from the more normal variety by the fine construction.

Although found on other Caribbean islands, this is the first time this variety has been discovered in Jamaica.

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Living and Fossil Unicellular Algæ and Aplanospores

In studies of peat deposits from south-western Australia, a number of small fossil algæ have been found with a morphology similar to certain living polyhedral unicellular species of the family Oocystaceae of the Chlorococcales. The classification of this family is artificial[1] and is based on the type of colony produced. Genera which have been placed in the family include *Tetraedron*, *Desmatractum*, *Octogoniella* and *Scotiella*[1–3]. Two of these, *Octogoniella* and *Desmatractum*, have a peculiar form characterized by two envelopes, separated by a more or less wide space containing an aqueous mucilage. The inner envelope is delicate, while the outer is composed of two conical halves joined together in the median plane.

Three distinct fossil algae, which match the forms described, have been found preserved in Western Australian peats of various ages between 4000 B.C. and the present. These are illustrated in Fig. 1, Nos. 2, 4 and 7. The principal difference between the

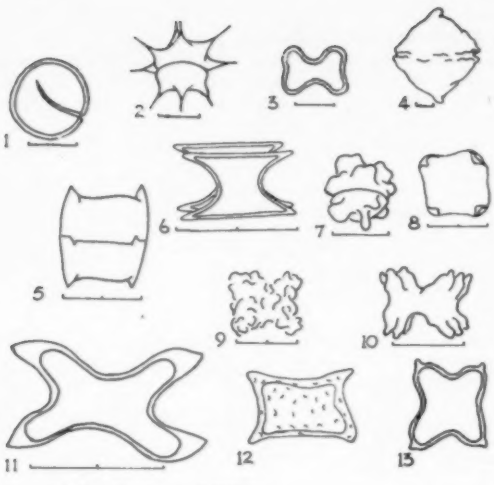

Fig. 1. Fossil algae of the Cyanophyceae: from a recent peat at Walpole (2 and 7) and Lake Muir (4). Fossil algal aplanospores: from a recent peat at Walpole (1, 5 and 11) and Lake Chittering (8). From a Lower Eocene glauconitic shale between 1,285 and 3,185 ft. in the Rottnest Bore (3, 9 and 10). From the Paleocene in the King's Park shale at 164 ft., Narrows Bore, No. 2 (6). Nos. 12 and 13 are living spores (refs. 2 and 3)

fossil forms and the living forms is the absence of the internal envelope of the protoplast, which is presumed to have been lost either after death of the organism, or during the processing of the peats for extraction of the microflora.

Fossil algal aplanospores have also been found preserved in peat sediments from a number of swamps and these are illustrated in Fig. 1, Nos. 1, 5, 8 and 11. Aplanospores are transported by the wind, as they have been found trapped with atmospheric pollen, in dried pinnules of tall *Schizaea* plants.

A palynological analysis of a peat profile from a swamp near Walpole, Western Australia, into which algal aplanospores are at present blown, suggested that a large number of the aplanospores were preserved under freshwater-lake conditions between 4700 B.C. and 600 B.C. Since then, with the rapid expansion of sedges and Hystrichosphaerideae, bog conditions have developed. Water in the bog has become more saline than in the lake and the number of preserved aplanospores diminished rapidly. The increased salinity is thought to favour germination of the aplanospores, after which they are no longer preserved.

Fossil aplanospores also occur in lower Tertiary glauconitic shales from the Perth Basin and these are illustrated in Fig. 1, Nos. 3, 6, 9, and 10. From finding these spores in sedimentary rocks, it is suggested that they may be of value as stratigraphic fossils and salinity indicators, while a detailed study of aplanospores from living families may enable a closer insight into the fossil history of the algae.

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Water-Soluble Methacrylates as Embedding Media for Preparation of Ultra-Thin Sections

At present, the embedding of preparations for cutting of ultra-thin sections is most frequently carried out by the procedure originally described by Newman *et al.*[1] and later perfected by a number of other authors[2–4]. This method, however, suffers from the drawback that the embedding media used are, in their monomeric form, immiscible with water and usually good solvents of fats. The preparation must be dehydrated—usually with alcohol or other organic solvent—before embedding and this, together with the solving of fats, may lead to the alteration of biological structures and formation of artefacts.

These disadvantages might be expected to be avoided by using an embedding medium which is completely miscible with water in its monomeric form. This condition is met by a mixture of two monomers prepared by Wichterle and Lím[5]—glycol monomethacrylate and triethyleneglycol dimethacrylate. These compounds are prepared by a procedure based on re-esterification of methyl methacrylate with ethylene glycol and triethylene glycol, respectively.

Both monomers are clear, colourless liquids at room temperature of a viscosity somewhat higher than that of water, and stable indefinitely at 0–4° C. The triethyleneglycol dimethacrylate serves as a cross-linking agent and is added in a ratio of about 1 : 100. When an accelerator is added (for example, ammonium persulphate) the polymerization proceeds uniformly at about 40–50° C. or under the influence of ultra-violet radiation for about 12 hr. and results in a clear, transparent polymer of three-dimensional structure. It was noted that polymerization is greatly accelerated by the presence of even traces of different co-catalysts, for example; also by osmium oxides. This is a particular advantage especially in the case of preparations fixed with osmium tetroxide. The final properties of the polymer—particularly its hardness—can be controlled by adjusting the ratio of the two monomers and especially the water content of the mixture.

Embedding in glycolmethacrylate for cutting ultra-thin sections can be carried out by two procedures. Since an isotonic aqueous solution of the monomers does not appear to cause alteration of biological materials, the structure of the preparation may first be fixed in a mild manner by polymerization in an isotonic monomer solution. Mechanical fixation of the biological structure is assumed after this first step, although a relatively soft polymer is formed. Further hardening of the primary gel is then achieved by stepwise replacement of the water by monomer followed always by polymerization.

Although it is a little time-consuming, this procedure, according to our preliminary results, appears to be milder than the alternative method in which the preparation is passed through a series of aqueous monomer solutions of gradually increasing concentration in the same way as is usual with alcoholic solutions.

Preparations embedded by either procedure show a satisfactory hardness. A disadvantage is a certain swelling of the block in water which results in a decrease in hardness during cutting. We are at present trying to eliminate this drawback.

The sections which we have obtained so far were found to spread very well on the surface of aqueous

ethanol containing lanthanum nitrate, and were easily picked up from the surface.

The technique for cutting ultrathin sections described here is being developed and further details will be published soon.

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A New Specimen of *Nipa* Fruit from Mohgaonkalan Cherts

The fruit *Nipa hindi* (Rode) Sahni was collected by Prof. K. P. Rode from Intertrappean beds of Mohgaonkalan, Chhindwara District, in 1933. So far it has been a holotype of *Nipa* from Deccan Intertrappeans of India.

A fresh specimen has been collected by me recently from the same locality. It differs from *Nipa hindi* (Rode) Sahni in size, shape, structure of internal seed, and the characters of the endocarp. However, the importance of the discovery of a new specimen is undoubtedly unique. Presence of *Nipa* fruit is very characteristic of the Eocene period; younger records are not yet known. Accordingly, on the discovery of Rode's only specimen of *Nipa hindi*, Prof. Sahni[1] had suggested an Eocene age for Intertrappeans at Mohgaonkalan. This new specimen falls in line and brings more support to Prof. Sahni's view on the age of the Deccan Traps of India. Hislop too had recorded this fruit in Deccan cherts in the publications by Carter[2], Hislop[3], and Hislop and Hunter[4]; but unfortunately his specimens are untraceable. Almost all the known records of *Nipa* show its existence roughly along the shore of the Nummulitic sea (Tethys), as indicated by Reid and Chandler[5], which probably extended from about north of Chhindwara.

Fig. 1. *Nipa* fruit from Mohgaonkalan cherts. ×0·6

Fig. 1 shows a complete fossil fruit comparable to modern *Nipa fruticans*. The fruit is a single-seeded drupe, slightly flattened, obovoid, with six longitudinal ridges which meet at the apical distinct umbo. It measures 6·5 cm. in length and 5 cm. in breadth at its broadest distal part. The carpel wall is thick especially at the apex. The epicarp is thin and smooth, the sarcocarp is about 10 mm. thick, and the endocarp is about 0·8 mm. thick. The single seed inside is slightly flattened, and has a prominent sulcus with endocarpic ridge dipping into it. The sulcus with the endocarpic ridge extends from the base to the top of the seed.

Preservation of the material is satisfactory and structural details are under further investigation.

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Variation in *Phytophthora palmivora* (Butl.) Butl. on *Theobroma cacao* L. in West Africa

Diseases of *Theobroma cacao* L., particularly pod-rot, caused by *Phytophthora palmivora* (Butl.) Butl., have been described in all the cocoa-producing areas of West Africa. A large collection of isolates from most territories, however, has shown that the nature of the pathogen varies greatly in the region and that at least two types of the fungus exist.

The first type of isolate, referred to as the Ghanaian type, is the dominant fungal pathogen in the more westerly cocoa-growing countries of Ghana, Ivory Coast, and Sierra Leone. This type occurs occasionally in Nigeria, Southern Cameroons, Gabon and the Belgian Congo. The isolates are characterized by cultural and morphological features typical of *P. palmivora*, and also have rapid growth-rates when inoculated into healthy pods. Minor differences have been found between isolates within the group, but for the most part they are indistinguishable.

The isolates of the second, or Nigerian, group, which are the dominant pathogens in the more easterly countries of Nigeria, Southern Cameroons, Fernando Po, French Cameroons and probably Gabon, show marked differences from the Ghanaian type. Cultural and morphological characters are very dissimilar, especially in growth-rates on artificial media and in sporangial dimensions, and the rate of lesion development in pods is both appreciably slower and very variable. Current tests have shown that complementary strains for oospore production occur within the group. Mixed cultures of the two groups of isolates grown on oatmeal agar at 60° F. have been found to produce oospores. Dimensions of these spores corresponded to those described by Ashby[1] on growing cultures of the 'cocoa' and 'rubber' groups of the fungus together under similar conditions. No oospore production has been obtained by cross in any isolates from the westerly group of countries.

The occurrence of complementary isolates within a particular territory could result in genetic variation of the organism and possible changes in its pathogenicity. Varieties of *Theobroma cacao* now being bred for resistance and tolerance to black-pod disease will need more extensive testing in areas where the pathogen is variable than may be necessary in Ghana, where it appears to be uniform. The variability of the organism must also be recognized when conducting bioassays of fungicides to be used in chemical control of the disease in the field.

Further investigations are proceeding, and a fuller account of the work will be published elsewhere.

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ANATOMY

A Reconstruction of the Foot of the 'Abominable Snowman'

The clearness of the tracks of the 'Snowman' shown in the photograph taken by Eric Shipton[1] (Fig. 1) has enabled me to make a reconstruction of its foot (Fig. 2). This has been used to produce imprints in snow which show a great similarity to the natural tracks (Figs. 1 and 3), suggesting that the model is accurate.

The plaster foot has the following anatomical peculiarities: (1) It is of great size: length 12½ in., fore breadth 7½ in., the width thus being 60 per cent of the length. The heel is 6½ in. broad—nearly as broad as the fore part of the sole. (2) The hallux is very thick and separated from other toes. (3) The second is the longest toe, and it is separated from the hallux and third toe; it is thinner than the hallux though more powerful than the other toes. (4) The third, fourth and fifth toes are small and united towards their bases, although the distal end of each toe gives a clear impression in the snow. The little toe is less bent than the others.

These features can be seen to a lesser degree in human and gorilla feet, and by comparing them certain inferences can be made.

(1) The 'Snowman' foot is as long as that of a large gorilla but much broader. Sir Arthur Keith[2] emphasized the increase of the tarsal, and decrease of the digital, elements of the skeleton of the foot during the evolution of higher primates. In the foot of the gorilla, the tarsal elements account for 39 per cent of the length measured along the third digit; in the human foot, it accounts for 52 per cent. At the same time, describing the soft tissues of sole, Keith states: "we see the enormous increase of the heel in the gorilla; it is relatively and absolutely larger than the heel area of man". Fig. 4 shows this huge foot and it can be seen that it resembles the much larger heel of the Snowman. This may equally be regarded as a combination of the hominoid tendency towards increasing length and breadth of tarsal bones together with gorilloid tendency for a spread of the soft tissues. The great fore breadth (42·8 per cent of the length) is found also in the skeleton of the foot of the neanderthaloid from the Kiik Koba cave in the Crimea[3].

(2) The hallux of the 'Snowman' resembles that of the gorilla, except that it is straighter, longer and much more powerful. In conjunction with the depth of the impression made in the snow, this suggests that it carried much of the weight of the body. But at the same time the hallux has every appearance of being opposable, and could be used to grasp objects or in climbing. The first row of foot bones is shortest because of a very shortened metatarsal element, although the phalanges themselves are big. R. Neuhaus[4] and H. Virchow[5] call such cases in human foot (Fig. 5) "zurücktretende" hallux and they appear, as in the 'Snowman', to be due to an unusually short metatarsal bone.

(3) The unusually large size of the second toe of the 'Snowman' can be also compared with the human foot with "zurücktretende" hallux. This type of big toe can be accompanied with an elongated and thickened second toe (Fig. 5). H. Klaatsch[6] has described a similar case in an Australian aborigine, who possessed the same type of foot which was able to grasp much better than normal. This is the same combination of shortened first and elongated second axis both in the foot of the 'Snowman' and in an abnormal human foot.

These peculiarities can be explained functionally. The hallux is shortened and capable of grasping, but

Fig. 1. The original track of the 'Snowman' (after Shipton). Copyright: The Mount Everest Foundation
Fig. 2. The reconstructed foot of the 'Snowman'
Fig. 3. Artificial track made with the reconstructed foot
Fig. 4. Plaster cast of a gorilla's foot

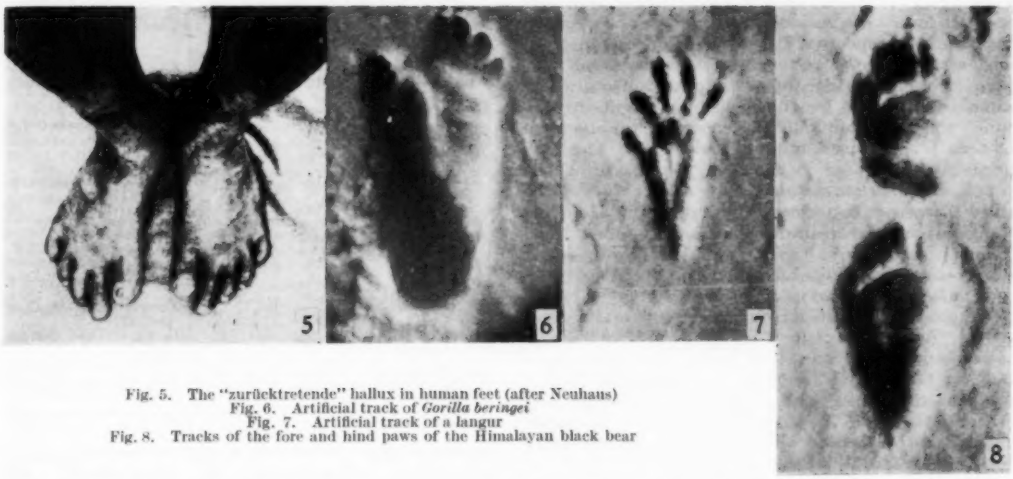

Fig. 5. The "zurücktretende" hallux in human feet (after Neuhaus)
Fig. 6. Artificial track of *Gorilla beringei*
Fig. 7. Artificial track of a langur
Fig. 8. Tracks of the fore and hind paws of the Himalayan black bear

less effective for use in walking upright. The second toe is therefore also involved in balancing and is elongated and thickened. This type of foot with its dual functions of grasping and balancing was probably characteristic of early prehominids in the first stages of the bipedal mode of life.

(4) The relative shortness of digits 3, 4 and 5 and their corresponding metatarsals are an obvious feature of the human foot. Also all three lateral toes of the 'Snowman' seem to show signs of partial syndactyly, but metatarsals 3–5 do not show any signs of the shortening which is observed in the human foot. The two distal phalanges of the little toe in the human foot are often fused together, and this condition may also explain the faintness of the impression made by the little toe of the foot of the 'Snowman', which we must suppose was held straighter than the others.

The impressions made by plaster casts of the feet of the mountain gorilla (Fig. 6), langur (Fig. 7) and the tracks from the preserved feet of black bear (Fig. 8) show that the footprint of the 'Snowman' is much like that of the gorilla and very different from the other two. Yet it has been suggested that Shipton's photograph was a footprint of either a bear or langur.

Other criticisms that the footprint of the 'Snowman' was deformed by the melting of the snow do not seem well founded, in view of the sharpness of the imprint and the similarity to the fresh artificial prints from the plaster model.

Hans Gross[7] mentions that good photographs of the tracks in the snow show even more details than do a plaster cast made from such tracks. But since heel and toes press more deeply into the snow than the sole, the arch of the foot is exaggerated and the impression is slightly shorter than the actual foot.

G. W. Gayer[8] stressed that the deepest impressions of human tracks are: the outer side of the back of the heel and on the inner side the big toe, and slightly less the outer side of the sole behind the little toe and the inner side behind the hallux. These details are well known from criminological studies and are very clearly seen in the tracks and plaster cast of the 'Snowman'.

In the original photograph it is also possible to see small heaps of snow thrown up by the back of the heel when it first touched the snow surface and was later pressed down by the flat of the heel, which is, according to Gayer, characteristic of the track of a bare human foot. This suggests that the track of the 'Snowman' was formed in the same way as a human one and that the 'Snowman' must walk in a human manner.

All the evidence therefore suggests that the so-called 'Snowman' is a very huge, heavily built bipedal primate, most probably of a similar type to the fossil *Gigantopithecus*.

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CYTOLOGY

Chromosomes of *Gyraulus circumstratius*, a Freshwater Snail

Polyploidy is relatively scarce in the animal kingdom, and is apparently almost entirely confined to those species in which reproduction is parthenogenetic, hermaphroditic or clonal[1]. Such animals usually do not have a heterogametous sex-determining mechanism to be disturbed by polyploidy. The hermaphroditic nature of freshwater pulmonate snails and their ability for self-fertilization[2] suggest the possibility that there might be a considerable degree of polyploidy among the large number of species of this group because a single accidental polyploid individual could give rise by self-fertilization to a polyploid strain, rather than producing only sterile triploids, if cross-fertilization were obligatory[3]. So far there has been little reliable evidence for polyploidy in aquatic pulmonate snails. (An earlier indication

of polyploidy, based on the chromosome numbers reported for *Physa gyrina*[4], and *P. acuta* (=*integra*?)[5] $n = 6$ and 18, respectively, is due to erroneous observations concerning *P. gyrina*). Six specimens of this species from several localities in Colorado from which animals were taken for the earlier investigation were found to have haploid chromosome numbers of eighteen (J. B. Burch, unpublished work). The high chromosome number ($n = c.$ 59) reported for the limpet *Ancylastrum costulatum* (=*Ancylus fluviatilus* Müller?) was not considered to be polyploid, but due to diphylogeny in freshwater snails[6].

During recent investigations of the chromosomes of freshwater snails we have had the opportunity to study *Gyraulus* (*Torquis*) *circumstriatus* (Tryon). Specimens were obtained from a mill pond on highway *M*–132, Section 5, Scio Township, Dexter, Washtenaw County, Michigan, U.S.A. Identifications were made by Dwight W. Taylor, U.S. Geological Survey. Duplicate shells have been deposited in the collections of the Museum of Zoology, University of Michigan (*UMMZ* 197464), and the United States National Museum (*USNM* 628895). The material examined consisted of ovotestes of ten specimens, all in active stages of gametogenesis. The tissues were sectioned and stained by Newton's crystal violet following fixation in Sanfelice, and acetic-orcein squashes were prepared following fixation in Newcomer's fluid[7]. Observations were made with a Tiyoda microscope using a ×90 (n.a. 1·25) oil immersion objective and ×10–30 oculars.

All specimens of *Gyraulus circumstriatus* were found to have thirty-six elements (presumably all bivalents) present during late prophase and metaphase of the first meiotic division of spermatogenesis (Fig. 1). So far as could be determined, the pairing behaviour of the bivalents appeared to be normal, and during diakinesis the paired chromosomes were held together by one or more chiasmata.

Exact counts on gonial metaphase cells could not be made, but they contained about seventy-two chromosomes. As seen in squash preparations gonial metaphase chromosomes are monocentric, with median, submedian, or subterminal primary constrictions. This is in contrast to the 'dot-like' mitotic chromosomes described from sectioned material of *Gyraulus hiemantium* and considered to be characteristic of aquatic pulmonate snails[8].

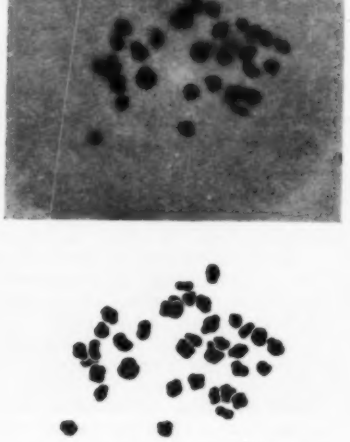

Fig. 1. Photograph and camera lucida drawing of prometaphase chromosomes of *Gyraulus circumstriatus* during the first meiotic division of spermatogenesis

Table 1. Chromosome Numbers in Planorbid Snails

Species	Haploid No.	Diploid No.	Investigator
Anisus vortex	18	—	Le Calvez and Certain (ref. 6)
Gyraulus hiemantium	16	32	Inaba and Tanaka (ref. 8)
G. deflectus	18	36	Burch (ref. 9)
G. circumstriatus	36	*c.* 72	Burch (ref. 9)
Biomphalaria glabratus	18	—	Azevedo and Gonçalves (ref. 11)
olivaceus	18	—	Burch (ref. 9).
Helisoma subcrenatum	—	36	Bonham (ref. 10)
H. anceps	18	—	Burch (ref. 9)
H. trivolvis	18	36	Burch (ref. 9).
Planorbarius corneus	17	—	Azevedo and Gonçalves (ref. 11)
P. cornuta (= *corneus* ?)	18	—	Le Calvez and Certain (ref. 6)
Promenetus exacuous	18	—	Burch (ref. 9).

Chromosome numbers found in planorbid snails are shown in Table 1. It is interesting to note that with the exception of two species, *Gyraulus hiemantium* (Japan) and *Planorbarius corneus* (Portugal?), all species other than *Gyraulus circumstriatus* have a haploid chromosome number of eighteen. It should be emphasized also that this is the haploid number of the only closely related North American species studied, *Gyraulus deflectus*. These numbers, together with the hermaphroditic nature and ability for self-fertilization of planorbid snails, strongly suggest that *Gyraulus circumstriatus* is polyploid, that is, tetraploid. If this is true it is the first case of polyploidy to be found in pulmonate snails. The apparent rarity of polyploidy in snails indicates that this is not a major factor in the evolution of this group.

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John B. Burch

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 9

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 4 p.m.—Prof. Feodor Lynen (Munich): "Co-enzyme A and Fat Metabolism".*

UNIVERSITY OF LONDON (at the Wright–Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Norfolk Place, London, W.2), at 5 p.m.—Prof. A. Neuberger, F.R.S.: "The Digestion and Absorption of Protein in Normal Man and in some Pathogenic Conditions".* (Second of four Almroth Wright Lectures. Further Lectures on May 16 and 23.)

UNIVERSITY COLLEGE (in the Gustave Tuck Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. T. Kotarbiński (Polish Academy of Sciences, Warsaw): "Some Reflections on Praxiology: The Effectiveness of Human Actions".* (Further lectures on May 11 and 13.)

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Prof. J. M. Kay: "The Generation of Power". (First of three Cantor Lectures on "Energy".)

Tuesday, May 10

UNIVERSITY OF LONDON (at the Institute of Obstetrics and Gynæcology, Hammersmith Hospital, London, W.12), at 2 p.m.—Prof. C. Scott Russell: "Pregnanediol".*

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Sir Olaf Caroe: "The Pathans" (Sir George Birdwood Memorial Lecture).

Wednesday, May 11

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. Alwyn Williams: "The Stratigraphy and Brachiopod Faunas of the Caradocian Rocks of the Girvan District, South-West Ayrshire".

UNIVERSITY OF LONDON (in the Wright–Fleming Institute Theatre, St. Mary's Hospital Medical School, Norfolk Place, London, W.2), at 5 p.m.—Prof. G. W. Thorn (Harvard): "Current Concepts: Glucocorticoids and Gluconeogenesis".*

INSTITUTION OF ELECTRICAL ENGINEERS, SUPPLY SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. G. Jancke: "The Development of the 400 kV. Network in Sweden".

UNIVERSITY COLLEGE (in the Physics Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. M. Nicolet (Institut Royal Météorologique de Belgique): "Solar Radiations and their Effects on the Upper Atmosphere".* (Further lecture on May 12.)

CHALLENGER SOCIETY (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—Annual General Meeting, followed by Dr. H. F. P. Herdman: "Modern Trends in Research Ship Design".

INSTITUTE OF PETROLEUM (at 61 New Cavendish Street, London, W.1), at 6 p.m.—Mr. C. M. Vignoles: "Petroleum People—Planning for To-morrow" (Presidential Address).

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. A. E. Adams: "A Recording Stereocomparator".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. O. R. Frisch, F.R.S.: "Are the Laws of Nature Symmetrical?".

Thursday, May 12

PHYSICAL SOCIETY, OPTICAL GROUP (at the National Physical Laboratory, Teddington, Middlesex), at 11.15 a.m.—Scientific Papers.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. P. M. S. Blackett, F.R.S., Mr. J. A. Clegg and Mr. P. H. S. Stubbs: "An Analysis of Rock Magnetic Data"; Prof. W. H. McCrea, F.R.S.: "The Origin of the Solar System".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. H. Mason: "The Resistance of Sheet Insulation to Surface Discharges".

ROYAL AERONAUTICAL SOCIETY, ASTRONAUTICS AND GUIDED FLIGHT SECTION (at the Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1), at 6 p.m.—Mr. J. E. Allen: "On Reducing Costs of Space Research".

Friday, May 13

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. V. A. Ambartsumiam: "The Evolution of Stellar Systems" (George Darwin Memorial Lecture).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT, Grade B (graduate, preferably possessing a degree which includes biological subjects and chemistry or physics) IN THE NATURAL SCIENCE DEPARTMENT, to teach biology to G.C.E. "A" level, human biology to G.C.E. "O" level, and elementary science—The Principal, Derby and District College of Technology, Kedleston Road, Derby (May 14).

ASSISTANT EXPERIMENTAL OFFICER (graduate in chemistry, but those graduating in 1960 considered), for soil and plant analysis with sugar beet field experiments, at first near Lincoln and later near Bury St. Edmunds—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (May 14).

LECTURERS and ASSISTANT LECTURERS (with research interests in inorganic chemistry, polymer chemistry or polymer physics) IN CHEMISTRY—The Registrar, Manchester College of Science and Technology, Manchester 1 (May 14).

LECTURERS or ASSISTANT LECTURERS IN MATHEMATICS—The Registrar, The Manchester College of Science and Technology, Manchester 1 (May 14).

RESEARCH ASSISTANT (qualified in biochemistry, physiology or zoology) TO THE PROFESSOR OF ZOOLOGY—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8 (May 14).

RESEARCH FELLOW IN ELECTROPHYSIOLOGY IN THE DEPARTMENT OF EXPERIMENTAL PSYCHIATRY, to take part in research into the actions of drugs on the brain in experimental animals and eventually be responsible for the primate section of this programme—The Assistant Registrar, The Medical School, The University, Birmingham 15 (May 14).

SENIOR LECTURERS IN METALLURGY, MATHEMATICS OR STATISTICS, PHARMACEUTICAL MICROBIOLOGY, and PHARMACOLOGY; and LECTURERS IN THEORETICAL CHEMISTRY, MATHEMATICS AND PHARMACEUTICS—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (May 14).

ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, The Queen's University, Belfast (May 16).

ASSISTANTS (3) (two in organic chemistry and one in inorganic chemistry) IN THE DEPARTMENT OF CHEMISTRY—The Secretary, The University, Aberdeen (May 20).

TUTORIAL STUDENT IN MECHANICAL ENGINEERING—The Registrar, King's College (University of London), Strand, London, W.C.2 (May 20).

ASSISTANT IN THE DEPARTMENT OF NATURAL PHILOSOPHY—The Secretary, The University, Edinburgh (May 21).

ASSISTANT (medical graduate, preferably with a B.Sc. degree in physiology) IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, University College, Earlsfort Terrace, Dublin (May 21).

DEMONSTRATOR IN AGRICULTURAL MICROBIOLOGY IN THE DEPARTMENT OF AGRICULTURAL SCIENCES, School of Agriculture, Sutton Bonington, near Loughborough—The Registrar, The University, Nottingham (May 21).

ASSISTANT LECTURER (with a good honours degree and preferably holding the degree of B.Sc.) in GEOGRAPHY—The Registrar, The University, Nottingham (May 23).

LECTURER (with qualifications in pure mathematics) IN MATHEMATICS—The Secretary, The University, 36 North Bailey, Durham (May 23).

SHELL STUDENTS (graduates in chemistry or engineering) IN CHEMICAL ENGINEERING—The Registrar, King's College (University of London), Strand, London, W.C.2 (May 26).

LECTURER IN METALLURGY—The Registrar, The University, Sheffield (May 28).

LECTURER (with a special interest in the philosophy of science) IN PHILOSOPHY—The Registrar, The University, Hull (May 30).

DEPUTY (with experience of handling animals and preferably a zoological background) TO THE DIRECTOR, Whipsnade Park, to assist the Director in the scientific and animal management work in the Park—The Secretary, Zoological Society of London, Regent's Park, London, N.W.1 (May 31).

LECTURER IN EDUCATION; and a LECTURER IN GEOGRAPHY in the Faculties of Arts and Economics, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 31).

LECTURER IN GEOLOGY with special reference to aspects of Economic Geology and, in particular, to the Geology of Coal and Oil—The Registrar, King's College (University of Durham), Newcastle upon Tyne 1 (May 31).

SENIOR LECTURER IN THE DEPARTMENT OF ANATOMY at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, May 31).

LECTURER IN THE DEPARTMENT OF FUEL TECHNOLOGY AND CHEMICAL ENGINEERING—The Registrar, The University, Sheffield (June 1).

UNIVERSITY LECTURER or DEMONSTRATOR (with qualifications in chemical or mechanical engineering, physical chemistry or physics) IN THE DEPARTMENT OF CHEMICAL ENGINEERING—The Secretary of the Appointments Committee, Department of Chemical Engineering, Pembroke Street, Cambridge (June 1).

LECTURER (with a qualification in biochemistry and preferably a medical qualification) IN CHEMICAL PATHOLOGY—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (June 4).

SENIOR TUTOR/DEMONSTRATOR IN PHYSICS at the University of Sydney, Australia—Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, June 4).

LECTURER (preferably with a medical degree) IN CHEMICAL PATHOLOGY at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (June 6).

CHAIR OF PHYSICS—The Registrar, The University, Birmingham 15 (June 15).

CLINICAL LECTURER (registered veterinary surgeon, preferably with an interest in obstetrics, infertility and in reproductive diseases) IN VETERINARY PRACTICE—The Registrar, Trinity College, Dublin (June 20).

SCIENTIFIC ASSISTANT (with a biological degree, the ability to write correct English and preferably some knowledge of foreign languages), for work which includes the abstracting and reviewing of biological literature—The Director, Commonwealth Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge (June 25).

LECTURER (with special qualifications or experience in inorganic chemistry) IN INORGANIC CHEMISTRY at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, June 30).

LINCOLN PROFESSOR OF CLASSICAL ARCHÆOLOGY AND ART—The Registrar, University Registry, Oxford (June 30).

RESEARCH STUDENTS (2) IN HISTORY OR ARCHÆOLOGY at the British Institute of History and Archæology in East Africa, Dar es Salaam—The Secretary, British Academy, Burlington House, Piccadilly, London, W.1 (October 31).

ASSISTANT, Grade B, TO TEACH BIOLOGY AND CHEMISTRY to G.C.E. Advanced Level with some general science—The Principal, Peterborough Technical College, Eastfield Road, Peterborough.

BIOCHEMIST (Basic grade)—The Secretary, St. Helier Hospital, Carshalton, Surrey.

CHAIR OF PHYSICS; and a CHAIR OF BIOLOGY in the Royal University of Malta—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

CHEMIST or BIOCHEMIST (with a good honours degree in chemistry or biochemistry and preferably with postgraduate experience) IN THE RADIOBIOCHEMISTRY DEPARTMENT, for biochemical research involving the use of radioactive isotopes and in particular carbon-14 and tritium—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 60/3.

INSTRUCTORS or ASSISTANT PROFESSORS (well qualified candidates) IN THE DEPARTMENT OF CHEMISTRY—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada.

LECTURER IN MATHEMATICS—The Registrar, Bradford Institute of Technology, Bradford 7.

MICROBIOLOGIST, to participate in research dealing with the origin, constitution and utilization of fossil fuels—The Secretary, Research Council of Alberta, 87th Avenue and 114th Street, Edmonton, Alberta, Canada.

PHYSICAL METALLURGISTS or PHYSICISTS (with research experience) IN THE PHYSICAL METALLURGY DIVISION, Department of Mines and Technical Surveys, Canada, to work with a group carrying out fundamental investigations in metal physics—Dept. M.T.S., National Employment Service of the Government of Canada, 61 Green Street, London, W.1.

PHYSICIST (basic grade)—The Secretary, Royal Free Hospital, Gray's Inn Road, London, W.C.1.

PRINCIPAL LECTURER IN NUMERICAL ANALYSIS, a SENIOR LECTURER IN STATISTICS, and an ASSISTANT LECTURER (Grade B) IN THE DEPARTMENT OF MATHEMATICS—The Principal, Welsh College of Advanced Technology, Cathays Park, Cardiff.

RESEARCH ASSISTANT (with a physics, mathematics or engineering degree, and interested in heat transfer and particularly in computational work in that field), for an original investigation into the transient temperature distribution in the rotors of steam turbines—Dr. R. D. Hoyle, Mechanical Engineering Department, City and Guilds College, Exhibition Road, London, S.W.7.

SCIENTIFIC OFFICER (with an honours degree in chemistry) at Northern Outfall Works, Beckton, London, E.6, for control, development and research—Medical Officer of Health (D.1/A), County Hall, London, S.E.1.

SENIOR GEOLOGIST (with a Ph.D. degree in sedimentary geology and an interest in stratigraphy) WITH THE PETROLEUM AND NATURAL GAS BRANCH of the Department of Mineral Resources, Regina, Saskatchewan, Canada, to prepare reports for publication on strata considered to have petroleum possibilities—The Agent-General for Saskatchewan, 19 Chester Mews, London, S.W.1.

SENIOR LABORATORY TECHNICIAN, to be responsible for the new physics teaching laboratories and lecture demonstrations up to degree standard—The Secretary, King's College, Strand, London, W.C.2, quoting Ref. 3072.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Northampton College of Advanced Technology. Report of the Governing Body for the year 1958–1959. Pp. 23. Prizes and Certificates, Session 1958–1959. Pp. 24. (London: Northampton College of Advanced Technology, 1960.) [172

Annual Review of the British Electronic Engineering Association, 1959. Pp. 28. (London: British Electronic Engineering Association, 1960.) [172

Cutrock Engineering Co., Ltd. Geological Laboratory and Field Equipment. Pp. iii+24. (London: Cutrock Engineering Co., Ltd., 1960.) [172

Report on Defence 1960. Pp. 18. (Cmnd. 952.) (London: H.M. Stationery Office, 1960.) 1*s*. net. [192

Ministry of Agriculture, Fisheries and Food. Bulletin No. 179: Identification of Seedlings of Common Weeds. By R. J. Chancellor. Pp. ii+72. (London: H.M. Stationery Office, 1959.) 4*s*. 6*d*. net. [192

Ministry of Agriculture, Fisheries and Food. Crop Protection Products Approved Scheme—Approved List 1959–60. Pp. 64. (London: Ministry of Agriculture, Fisheries and Food, 1960.) [192

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 1009, Vol. 252 (18 February 1960): On Adsorption at the Oil/Water Interface and the Calculation of Electrical Potentials in the Aqueous Surface Phase. 1: Neutral Molecules and a Simplified Treatment for Ions. By D. A. Haydon and F. H. Taylor. Pp. 225–248. 7*s*. 6*d*. No. 1010, Vol. 252 (18 February 1960): The Cauchy Problem for Elastic Waves in an Anisotropic Medium. By G. F. D. Duff. Pp. 249–273. 8*s*. No. 1011, Vol. 252 (18 February 1960): Atmospheric Waves Caused by Large Explosions. By J. N. Hunt, R. Palmer and Sir William Penney. Pp. 275–315. 13*s*. (London: Royal Society, 1960.) [192

B.C.I.R.A. Journal, Vol. 8, No. 1 (with which is incorporated the B.C.I.R.A. Bulletin and Foundry Abstracts). Pp. 162. Subscription rates: Sterling area £6 6*s*. 0*d*. per annum; Dollar area 20 dollars per annum. (Alvechurch, Birmingham: British Cast Iron Research Association, 1960.) [192

British Steel Castings Research Association. Data Sheets on Moulding Sands. Second, revised and enlarged edition. Pp. x+45. (Sheffield: British Steel Castings Research Association, 1960.) 30*s*. [192

Scientific Council for Africa South of the Sahara. Publication No. 37: Tenth Meeting of the Scientific Council, Kampala, 1959. Pp. 135. (London: Secretariat, C.C.T.A./C.S.A., Abbey House, Victoria Street, 1959.) [192

Research in Veterinary Science, Vol. 1, No. 1 (January 1960). (A Journal of the British Veterinary Association.) Pp. 93. Published quarterly. Annual subscription: 90*s*. post free. Single issues 25*s*. (Oxford: Blackwell Scientific Publications, 1960.) [192

Beyond Nihilism. By Prof. Michael Polanyi. (The Thirteenth Arthur Stanley Eddington Memorial Lecture, 16 February 1960.) Pp. iv+37. (Cambridge: At the University Press, 1960.) 3*s*. 6*d*. net. [192

British Universities Film Council. The Use of Film in Teaching and Research in British Universities 1959. (A Report of an investigation carried out in selected University Departments by a Sub-committee: G. E. H. Foxon, G. H. Bell, and C. J. Duncan.) Pp. 24. (Newcastle upon Tyne: C. J. Duncan, Hon. Secretary, British Universities Film Council, c/o The Medical School, King's College, 1960.) [192

Planning, Vol. 26, No. 439 (22 February 1960): The Market for Coal. Pp. 37–64. (London: Political and Economic Planning, 1960.) 3*s*. [192

Building Research Station Digest, No. 131 (February 1960): External Rendered Finishes. Pp. 4. (London: H.M. Stationery Office, 1960.) 4*d*. [192

Other Countries

United States Department of the Interior: Geological Survey. Water-Supply Paper 1308: Compilation of Records of Surface Waters of the United States through September 1950. Part 5: Hudson Bay and Upper Mississippi River Basins. Prepared under the direction of J. V. B. Wells. Pp. v+708+1 plate. Water-Supply Paper 1315–A: Compilation of Records of Surface Waters of the United States through September 1950. Part 11–B: Pacific Slope Basins in California, Central Valley. Prepared under the direction of J. V. B. Wells. Pp. v+458+1 plate. Water-Supply Paper 1503: Surface Water Supply of the United States, 1957. Part 2–A: South Atlantic Slope Basins, James River to Savannah River. Prepared under the direction of J. V. B. Wells. Pp. viii+323. 1.25 dollars. Water-Supply Paper 1507: Surface Water Supply of the United States, 1957. Part 4: St. Lawrence River Basin. Prepared under the direction of J. V. B. Wells. Pp. ix+379. 1.25 dollars. (Washington, D.C.: Government Printing Office, 1959.) [192

United States Department of the Interior: Geological Survey. Professional Paper 313–A: The Phosphoria, Park City and Shedhorn Formations in the Western Phosphate Field. By V. E. McKelvey and others. Pp. v+47+3 plates. 1 dollar. Professional Paper 316–C: Regional Geophysical Investigations of the Lisbon Valley Area, Utah and Colorado. By P. Edward Byerly and H. R. Joesting. Pp. iii+39–50+plates 6–9. Professional Paper 354–A: Intrenched Meanders of the North Fork of the Shenandoah River, Virginia. By John T. Hack and Robert S. Young. Pp. iii+10+1 plate. 20 cents. (Washington, D.C.: Government Printing Office, 1959.) [192

Chicago Natural History Museum. Fieldiana: Zoology, Vol. 41, No. 2: Birds from Gabon and Moyen Congo. By Austin L. Rand, Herbert Friedmann and Melvin A. Taylor, Jr. Pp. ii+221–411. (Chicago: Chicago Natural History Museum, 1959.) 3.50 dollars. [192

Transactions of the American Philosophical Society, New Series, Vol. 50, Part 1: Contemporary Japan: The Individual and the Group. By Y. S. Matsumoto. Pp. 75. 2 dollars. Vol. 50, Part 2: Studies in Byzantine Astronomical Terminology. By Prof. O. Neugebauer. Pp. 45. 1.50 dollars. (Philadelphia: American Philosophical Society, 1960.) [192

Bulletin of the Florida State Museum, Biological Sciences. Vol. 5, No. 2: A Bilaterally Gynandromorphic *Hypodynerus*, and a Summary of Cytologic Origins of Such Mosaic Hymenoptera. Biology of Eumenine Wasps, VI. By Kenneth W. Cooper. Pp. 25–40. 35 cents. Vol. 5, No. 3: How Many Species of Birds have Existed. By Pierce Brodkorb. Pp. 41–53. 25 cents. (Gainesville, Fla.: Florida State Museum, 1959 and 1960.) [192

United States Department of the Interior: Fish and Wildlife Service. Fishery Bulletin No. 163: Contributions of Hudson and Connecticut Rivers to New York–New Jersey Shad Catch in 1956. By Kenneth J. Fischler. Pp. iv+161–174. (Washington, D.C.: Government Printer, 1959.) 20 cents. [192

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